EDUCATION OF THE CENTRAL NERVOUS SYSTEM

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EDUCATION OF THE CENTRAL NERVOUS SYSTEM

A STUDY OF FOUNDATIONS, ESPECIALLY OF SENSORY AND MOTOR TRAINING

BY

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New York
THE MACMILLAN COMPANY
LONDON: MACMILLAN & CO., LTD.
1897

Set up and electrotyped September, 1896. Reprinted January, 1897.

Norwood Press
J. S. Cushing & Co. — Berwick & Smith
Norwood Mass. U.S.A.

"In all the higher processes of the brain we must recognize that, in nervous material at all events, action determines structure, meaning by structure molecular arrangement and disposition."

DR. M. FOSTER, F.R.S.

"Every cerebral element is subject to the educating influence of those sensory nerve fibres with which it is anatomically connected." HERING.

"Just as muscular exercise causes an increased growth of muscular fibre, so regulated mental exercise must develop and strengthen the tissue of the brain."

DRS. M'KENDRICK AND SNODGRASS.

"The goal attained by the process of practice is simply the mechanization of movements which were originally dependent upon psychical antecedents. That must mean that mechanical, *i.e.* physiological, alterations are at the bottom of the whole matter." WUNDT.

"Race, age, and previous training seem to have a marked effect in determining the extent and character of the reflex actions which the spinal cord is capable of carrying out."

DR. M. FOSTER, F.R.S.

"Everywhere where there is development later events are conditioned by earlier." HÖFFDING.

PREFACE

THE old theory that education consists solely in modifications in an immaterial entity has worked untold damage. It was argued that the immaterial never grew old, and that it could be trained as well at one time as at another. From this mistaken notion arose such adages as, "It is never too late to be what you might have been." It would be nearer the truth to say of any creature whose higher knowledge rests upon sensory foundations, or, in other words, upon modifications in nerve cells: "It is always too late to be what you might have been." Education may be something more, as the writer believes, than modifications in the central nervous system, but it is also true that without these modifications no mortal can be educated.

If brain cells are allowed to pass the plastic stage without being subjected to the proper stimuli or training, they will never fully develop. The majority of adults have many undeveloped spots in their brains.

This book calls attention to the importance of early purposive training of the central nervous system while its brief morning of plasticity lasts. Then, and only then, can the nerve cells be made lifelong friends, who will take upon themselves the duty of pronouncing correctly, of speaking grammatically, of making habitually correct responses to the thousand and one demands of life, while the intellectual powers are left free to devote their entire energies to weightier matters. Such nerve cells will also be ready to reproduce their former sensory experiences as a firm foundation for thinking about concrete things. Rightly trained nerve cells occupy a position analogous to that of a trusty servant, who, without being looked after, attends to all the wearying details of housekeeping, leaving the mistress free to entertain her friends and to develop her higher powers. No human being knows a more relentless enemy than motor nerve cells which have been wrongly trained early in life. Such a man may be worth a million, but the bad grammar will continue to flow automatically from the motor mechanism of speech, and to mortify him in good society.

It has been known for some time that the higher processes of thought are dependent on modifications in brain cells, and that the highest intellectual superstructure can be no firmer than the sensory foundation, but this knowledge has not been properly applied in training these cells. Practical application of truths lags far behind a theoretical knowledge of them.

The principal object of this book is to prescribe for our complex central nervous systems at the proper time the special kinds of exercise, sensory, motor, and ideational, demanded for full development. A person who has only one or even two senses properly trained is at best a pitiful fraction of a human being. The writer has endeavoured to present herewith some facts which every parent and teacher must know and apply in order to secure the fuller development of children at a critical time.

A special feature of this work consists in showing that recalled images of sense objects are powerful and necessary aids in further modifying and developing the sensory cells; not images of sight alone, but of *every* sense.

Many examples of sensory objects have been taken from literature to indicate the proper direction for training. Theory often fails because objects demanding constant practice are not at hand or suggested. Almost all study English literature, which constantly presents objects requiring sensory interpretation for their proper understanding. For this reason, numerous examples, especially from Shakspere and Milton, have been quoted to show how the study of literature may be made to react on sensory training. From long personal experience, the author can testify that the majority of pupils can soon be induced to seize the first opportunity to obtain definite sensory knowledge of any object mentioned in poetry, whether of a daffodil, of a murmuring pine, or of "incense-breathing morn." It is hoped that the chapter on "How Shakspere's Senses Were Trained" may be found practically serviceable in educating the central nervous system of youth.

It has been the aim of the author to restrict this work to its own proper field of training and developing the central nervous system, and not to offer these chapters as a substitute for the thorough study of psychology.

Acknowledgment is made to Professor Donaldson's excellent work, *The Growth of the Brain*, — although the following chapters do not view the subject in as fatalistic an aspect as that work, — and to Dr. August Schachner for much scholarly help in dissections of the central nervous system.

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CHAPTER I

The Central Nervous System

Anatomical and physiological details are usually uninteresting except to physicians and to a few other specialists. It is the purpose of this chapter to give only those facts necessary to render more intelligible what we have to say about the training of the central nervous system. An anatomical or a physiological fact is utterly worthless unless it can be assimilated to other ideas to render them more clear. When we come to speak of undeveloped brain tracts, the terms will mean little, unless we can construct definite images of the various cerebral areas. But if we know precisely what part of the brain is undeveloped, the necessity for its improvement will be more forcibly realized, and directions for the proper exercise will lay a stronger hold on the attention.

The mind insists on investing all its knowledge with two primal relations, those of space and time; the where and the when are questions instinctively asked. A gentleman who had often heard the Turkish question and the approaches to the Black Sea discussed, was haunted by a sense of unrest whenever he heard the Dardanelles and the Bosphorus mentioned. Occasionally the term "Hellespont" was used, and he did not know with which strait to identify that name. He was neither sure of the exact position of Constantinople, nor of the bodies of water which the straits connect. Finally he could no longer endure the mental disquiet over the ignorance of the spatial relations, so he consulted an atlas, formed an image of a gourd with two handles, — the longer handle being the Dardanelles or Hellespont, the body of the gourd the Sea of Marmora, the shorter handle the Bosphorus, — and felt a sense of relief in having satisfied a primal demand of the mind. In the same way the mind demands a map of the central nervous system before remarks about developing certain parts can be fully realized. An idea as rude as that of the gourd in the case just mentioned is far better than an idea without form and therefore essentially void.

When we speak of developing certain parts of the brain, or of lack of development in certain tracts because of deficiency of early training, we may be said to assume the theory of definite cerebral localization, as opposed to the dynamic or vibratory theory. We wish here to call attention to the fact that these theories, within certain limits, are not necessarily in conflict with each other. It may be true that certain dynamic combinations or vibrations in the same part of the brain may mean different things, just as different rates of vibration in the same ether may cause heat, light, and electricity. But even dynamic combinations or differing rates of molecular vibration must have a local habitation in the brain. If any special tract is not early subjected to all the dynamic combinations or vibrations of which it is capable, that tract is in so far undeveloped.

It may be true that the same fingers can play the piano, grasp a knife, lift a weight, or paint a picture, but it is also true that the muscles in the fingers cannot do the work of the jaws or the legs, nor can the ear take the place of the eye. The muscles in one part of the body may be well exercised and strong, while those of another part may be comparatively little used, and hence weak. The fact that the body is a unit and that the same blood courses to all parts of it, must not cause us to shut our eyes to these undoubted facts of localization of function. We know that special exercise develops special muscles. We also know that, if the sense of sight is trained, while hearing receives no education, the brain tract correlated with hearing will not be proportionately developed.

As organisms grow more complex, there is more specialization of function. Some of the lower forms of animal life may have what answers for a stomach wherever nutriment happens to come in contact with the body, but this is not true of the higher forms of animal life. This greater differentiation with advanced forms of life entails new responsibilities in demanding the proper exercise for the more complex parts, not one of which must be neglected.

The best authorities agree that nerve matter shows increasing specialization with advancing intelligence. Dr. M. Foster says: "Thus when we survey a series of brains in succession, from the more lowly frog, through the bird, the rabbit, the dog, and other lower mammals up to the monkey, the anthropoid ape, and so to man himself, we find an increasing differentiation of the cerebral cortex, by which certain areas of the cortex are brought into special connection with certain skeletal or other muscles in such a way that stimulation of a particular portion of the gray matter gives rise to a particular movement and to that alone."[1] Professor Donaldson says: "Experi-

[1] Foster's *Text-book of Physiology*, p. 749.

ment shows that in man the special cortical centres are somewhat separated from one another, and this separation is due to masses of brain substance which do not give reactions upon ordinary electrical stimulation."[1] We allude to these facts here, since the insistence of special forms of exercise to develop the complex central nervous system is the chief purpose of this work.

The central nervous system, which we shall now proceed to map out, is composed of the encephalon, or contents of the skull, and the spinal cord. All masses of nerve matter, as soon as they leave the brain or spinal cord, are called the peripheral nervous system. The central nervous system is therefore what we popularly mean by the brain and spinal cord.

This system consists of nerve cells and fibres, the latter being in every case the outgrowth of cells. Different cells in varying parts of the body are connected by nerve fibres, in much the same way that New York is connected with Chicago by telegraph wires. The analogy is more striking than appears at first sight because after nerve fibres leave a cell, they have never been seen, even with the strongest microscope, to enter another cell. There is some mysterious physiological, but no anatomical, connection. When a New Yorker telegraphs a man in Chicago, the home of the resident of Chicago may be at some distance from the ending of the wire. A person from another planet might wonder for a long time how the despatch could reach the person, just as we are now wondering how an impulse from one nerve cell reaches another. There is probably some intermediate conductive matter which does the work of transmission in a way analogous to that of the telegraph boy.

The cells of the central nervous system are chiefly composed of a wonderful protoplasmic matter in which minute granules

[1] Donaldson's *The Growth of the Brain*, p. 265.

and striations can be detected. We are not acquainted with any substance which is more sensitive to the most delicate stimulation, or which better retains modifications due to past experience. There are instruments which can detect a change in the brain, caused by the passing of a cloud over the sun. An old man said that his brain cells still retained modifications from a glance at a rainbow on a certain summer's evening,

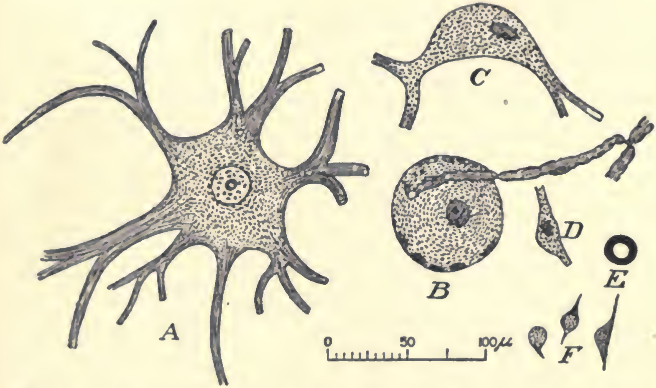

Fig. 1. — "A group of human nerve cells drawn to scale × 200 diameters. *A*, cell from ventral horn of spinal cord; *B*, cell from the spinal ganglion of dorsal root, with its nerve process; *C*, cell from the column of Clarke; *D*, solitary cell from the dorsal horn of the spinal cord; *E*, cross-section of a large nerve fibre; *F*, granule cells from the cortex of the cerebellum." — DONALDSON, after WALLER.

seventy years before. Man's entire central nervous system is computed to have at least three thousand million nerve cells. These vary in diameter from about $\frac{1}{250}$ to $\frac{1}{3500}$ of an inch.

Nerve cells have the power of sending out processes which we term nerve fibres. It is their function to connect all the nerve cells in the various parts of the body. Just as a prosperous country is threaded with telegraph wires, which keep all its cities aware of what is happening elsewhere, so the human body is traversed by nerve fibres which report stimuli, transmit impulses to movement, and perform various other offices connected with the nutrition, circulation, and secretions of the body. Some idea of the fineness of these fibres may be gained from the number of sensory nerves that end in the brain. Specialists estimate this number at not less than two and one-half millions.

There are two classes of nerve fibres, *afferent* and *efferent*, those concerned in transmitting stimuli of any kind to the central nervous system and those engaged in bringing impulses from it. We are here concerned with only one species of the class of afferent nerves; namely, *sensory* nerves. These transmit any kind of sensory stimulation, such as sound, light, or odour. The only species of efferent nerves in which we are at present interested are *motor* nerves, or those which transmit impulses to move the muscles. Our entire intellectual life rests on a foundation of sensation and movement.

As soon as we have a sensory nerve leading to a nerve cell, in the spinal cord, for instance, and a motor nerve issuing from the same cell, we have the elements concerned in reflex action, which is so important in human life and education. Reflex action is simply a sensory impulse turned back along a motor nerve by a nerve cell. If we touch or slightly pinch the hand of a sleeper, it will be withdrawn without his waking. A sensory nerve reports the stimulus to a nerve cell in the spinal cord, and this cell changes the direction of the impulse, sending it back along a motor nerve to the muscles concerned in moving the hand and causing contraction in them. Reflex action may take place without consciousness or brain intervention. Were it not for reflex action, we could make but comparatively little progress in life. We should then be in a position similar to that of the manager of an industrial concern, who could not answer a single letter or transact any business by deputy. He could do no more business than his limited time would allow him to oversee personally. Reflex action is the deputy of the brain, and directs myriad movements, thus leaving the higher powers free to attend to weightier things. Nerve action of this kind is so very important that we shall consider it at greater length in the next chapter. Suffice it for the present to say that so great a physiologist as Dr. M. Foster declares that reflex action can be modified by training.

Thus far we have been considering the units common to the entire central nervous system, — nerve cells and their outgrowth, nerve fibres. We may now consider the individual members of this system, and turn our attention first to the spinal cord, the great organ of reflex action.

The spinal vertebræ pass down the rear median part of the trunk of the body for about a foot and a half, and enclose a remarkable cord of nervous matter. The spinal cord is composed of a gray and a white substance, and, like the brain, is almost divided into two parts. Two deep fissures, an anterior and a posterior, nearly meet, leaving two crescents of gray matter connected by a narrow bar.

The spinal cord gives off thirty-one pairs of nerves which supply the trunk and limbs. The nerves leave each half of the spinal cord in pairs, passing out from the tip of each crescent of gray matter. The anterior and the posterior bundles of nerves combine to form one nerve trunk, soon after leaving the spinal cord.

The motor nerves leave by the anterior horns, the sensory, by the posterior horns, of gray matter. The motor nerves pass to the muscles and transmit to them incentives to movement. The sensory nerves extend to the skin. There is probably not a city in the world that has as many telegraph wires entering it as there are nerves in the spinal cord, leading to the brain. The anterior roots of a frog's spinal nerve were found by actual count to contain from 5,000 to 11,000 separate nerve fibres, the number varying with the size and age of the frog. When the cord is sufficiently injured, the portions of the body sup-

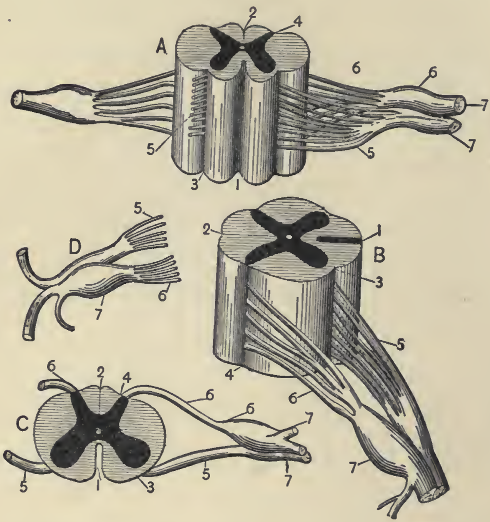

Fig. 2. — Different aspects of sections of the spinal cord and of the roots of the spinal nerves from the cervical region: 1, different views of anterior median fissure; 2, posterior fissure; 3, anterior lateral depression, for anterior roots; 4, posterior lateral depression, for posterior roots; 5 and 6, anterior and posterior roots, respectively; 7, complete spinal nerve, formed by the union of the anterior and posterior roots. — HALLECK'S *Psychology*, from ALLEN THOMPSON.

plied with nerves leaving the cord below the seat of the injury suffer both motor and sensory paralysis. Such a limb would have no power to move, and it might be sawed off without pain. The brain's chief deputy is the spinal cord, which, through its powers of reflex action, attends to much of the routine business of the body, leaving the energy of the brain more free to expend itself in other directions.

Passing next to the encephalon, or contents of the skull, we may distinguish between the medulla oblongata, the cerebellum, and the cerebrum. These three form the major divisions of the contents of the skull. There are in addition some other basal ganglia, which it is not necessary to describe here.

The medulla oblongata is really the enlarged upper end of the spinal cord. The medulla, which is only about an inch and a quarter long, is an organ of greater complexity than the spinal cord and is capable of a greater variety of actions. The innumerable fibres from the cord pass through it, and many of them here decussate, or cross to the opposite side. Thus, a motor fibre in connection with the right foot would pass over into the left half of the medulla and end in the left side of the brain. Reflex centres of a high order are found in the medulla.

Next comes the cerebellum, or little brain, which is situated at the rear part of the base of the cerebrum, or larger brain. The cerebellum is concerned in some unknown way with coordinating the muscles and balancing the body. If we could, with an eye manifold finer than the finest microscope, look at the cerebellum of a man staggering under the effects of strong drink, we should probably be able to find traces of disorder there.

The cerebrum occupies the upper part of the skull. It is not necessary for our purpose to know all the minute anatomy of the brain, but we must so map it out as to be able to understand what is meant by the development of its various parts.

The brain is divided into two symmetrical hemispheres, the right and the left.

The first landmarks to be learned on the outer surface of the brain are the fissure of Rolando and the fissure of Sylvius. The fissure of Rolando extends from the middle upper part of the brain downward and forward, passing a little in front of the ear, and stopping before reaching the fissure of Sylvius. This latter fissure begins at the base of the brain and runs back-

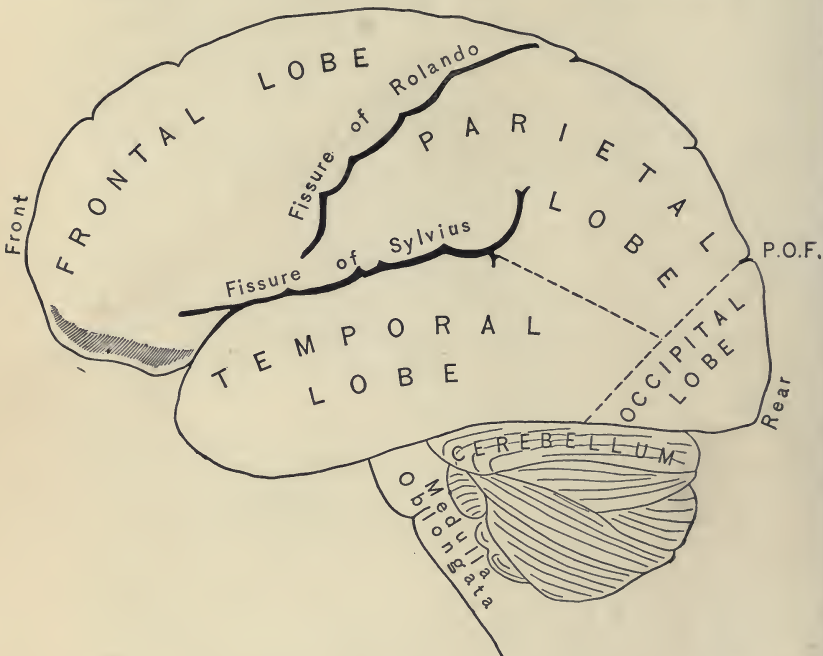

Fig. 3. — Diagrammatic view of the left cerebral hemisphere, showing the four lobes, the two principal fissures, the cerebellum, and the medulla oblongata.

ward and upward, at an acute angle with the base of the brain (see Fig. 3).

There are on the outer lateral surface of each hemisphere four lobes or major divisions of the brain. These lobes are in turn subdivided by smaller fissures into various convolutions.

The four lobes are placed as follows: The frontal lobe is that portion of the cortex of the front of the brain extending backward to the fissure of Rolando, and downward to the base of the brain and the fissure of Sylvius. The parietal lobe is that portion of the brain immediately behind Rolando, extending downward to Sylvius and backward to the parieto-occipital fissure (marked *P. O. F.* in Fig. 3). The occipital

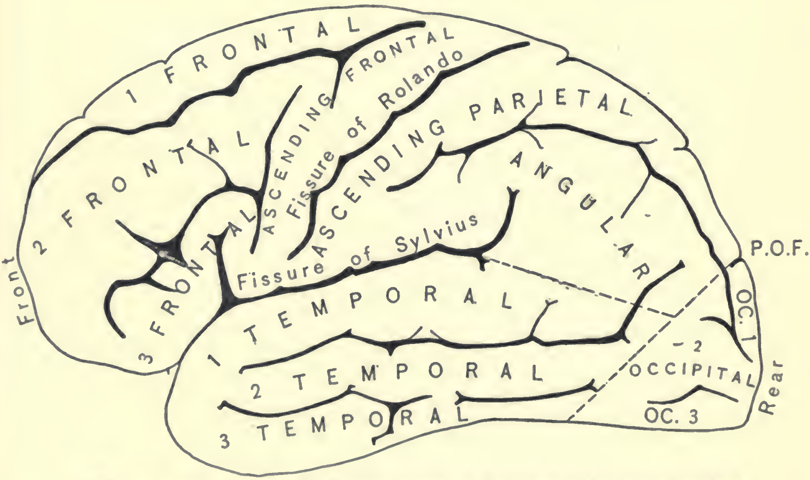

Fig. 4.—Showing the chief convolutions on the lobes of the lateral surface of the left hemisphere of the brain.

lobe extends from the parietal down to the base of the brain. The temporal lobe lies below Sylvius and extends backward to an ill-defined boundary between the parietal and the occipital lobes, and downward to the base of the brain.

Each of the lobes we have been considering is divided by fissures into more or less distinct convolutions. For instance, the frontal lobe is divided into the first, second, third, and ascending frontal convolutions. The position of the most important lateral convolutions may be seen by referring to Fig. 4.

The convolutions of the inner halves of the hemispheres are not so easily understood without a model. Figure 8, p. 18, shows as well as a diagram can the leading mesial convolutions.

Our next step is to determine what parts of the brain are exercised by the various sensory and motor stimuli of life. We can then attach some definite meaning to an undeveloped brain spot, — give it a local habitation and a name.

Localization of brain function has only recently been demonstrated. There is nothing surprising in the fact that different parts of the brain should have different functions. We might infer in advance that such would probably prove to be the case. Dr. Michael Foster says of the human body as it develops, "Some cells put on certain characters, and others other characters; that is to say, the cells undergo *histological differentiation*. . . .

"This histological differentiation is accompanied by a *physiological division of labour*. . . . Instead of all the units as in the amœba doing the same things equally well, the units of one tissue are told off as it were to do one thing especially well, or especially fully, and thus the whole labour of the body is divided among the several tissues."[1]

One of the important functions of the brain is to send out automatic motor impulses. We decide to pick up a pen, to move a foot, to utter a word, and we voluntarily innervate a certain portion of the brain. If the nerves leading from this to the proper muscles are unimpaired, the motion follows. The motor functions of the brain are the most accurately localized of all.

The motor zone is that part of the brain adjacent to the

[1] Foster's *Text-book of Physiology*, p. 6.

fissure of Rolando. If we were to take a monkey, and remove the skull over the fissure of Rolando for a short distance on both sides of it, we should expose the motor zone. We could prove this by exciting various portions of this tract with an electric current. If the brain at the extreme upper portion of Rolando was excited, the monkey's leg would be moved. If the current was confined to a certain small part of this area

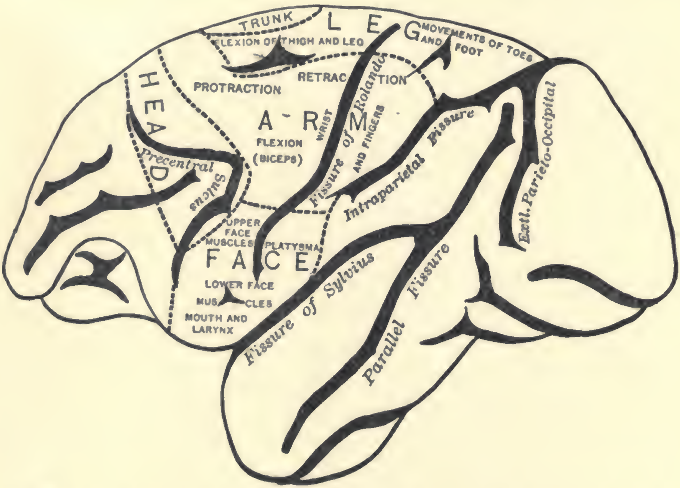

Fig. 5. — Lateral surface of a monkey's brain, showing the motor centres. — HALLECK'S *Psychology*, from HORSLEY and SCHAFER.

(see Fig. 5), only a toe might be flexed. Repeated experiments were successful in mapping out a motor region so exact that such small centres as those concerned in moving a thumb or contracting the larynx have been located. While it is true that these areas were originally localized on the monkey's brain by stimulating different points with electricity, there is sufficient similarity between the human and the simian brain, to warrant locating the principal areas in corresponding places on the human brain. The chief fissures are the same in both brains. Of course, human beings cannot be directly experimented with in this way, but monkeys have been especially serviceable to human beings along this line.

A few years ago the boldest surgeon would have hesitated to cut into the brain, even when there were symptoms that some-

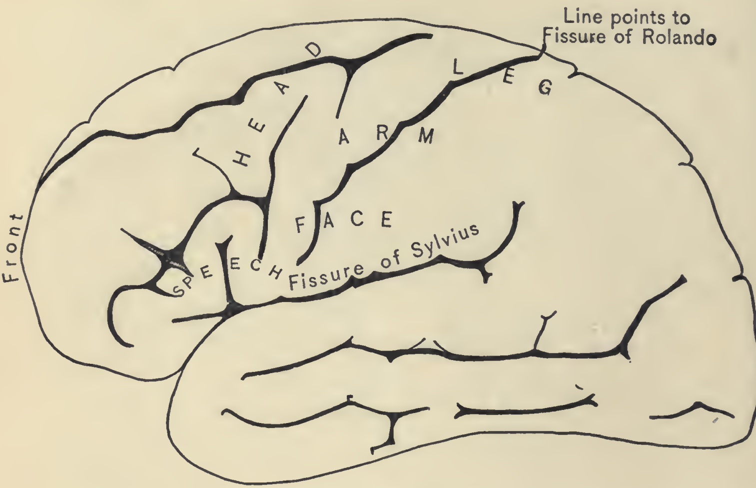

Fig. 6. — Diagram of motor localization in the human brain.

thing serious must be the matter with it. In the last decade of the nineteenth century a physician can write, "When I say that the existence of a tumour about the size of the end of the forefinger can be diagnosticated, and that before touching the head it should be said (and I was present when the statement was made) that it was a small tumour, that it did not lie on the surface of the brain, but a little underneath it, and that it lay partly under the centre for the face and partly under that for the arm in the left side of the brain, and that the man was operated on, and the tumour found exactly where it was believed to be, with perfect recovery of the patient, it is something which ten years ago would have been deemed the art of a magician rather than the cold precision of science."[1]

In the case of an epileptic patient, it was noticed that a preliminary twitching always began in the left shoulder. The surgeons cut a circular hole through the right side of the skull immediately over the shoulder centre. Beneath the incision they found a small tumour, which they removed. A sewing-girl was subject to fits of epilepsy, and it was observed that the preliminary convulsive twitching always began in the right thumb. The surgeons cut through the skull directly over the motor centre for the hand. They then stimulated the brain cortex until they found a surface where the thumb alone was flexed. It was necessary to determine this point accurately, for if the brain beyond this was injured, the hand and entire arm would be paralyzed, and the poor sewing-girl could then no longer earn her living. The surgeons succeeded in removing the thumb centre alone, and, as a result of the operation, her epileptic attacks were fewer and milder in number. She also had the use of her hand.

The important motor centre for speech lies in the third left frontal convolution for right-handed people, and in the corresponding convolution on the right side of the brain in the case of those left-handed (see Fig. 6). When we wish to talk, we must innervate that portion of the brain. If a person understands what is said to him, but is unable to control his organs of speech so as to reply, he is said to be suffering from motor aphasia. Since the centre for hearing lies in a different part of the brain, the unfortunate may understand

[1] *Vivisection and Brain Surgery*, by W. W. Keen, M.D.

everything that is said to him and yet be unable to utter a word in reply. If his hand centre is unimpaired, he may write answers to questions as well as ever. No one can be an intelligent student of memory if he does not know such facts as these.

We must now consider in what part of the brain the various nerves of the special senses discharge the stimulus which they

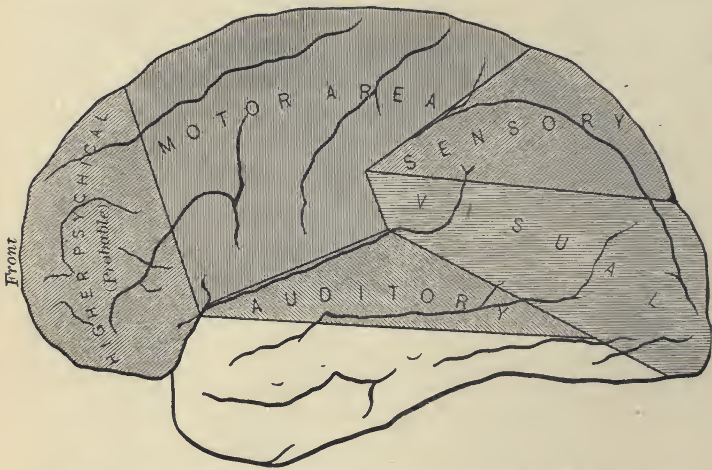

Fig. 7.—Side view of left hemisphere of human brain, showing the principal localized areas.—HALLECK'S *Psychology*.

bring. We shall find the sensory areas less definitely mapped out than the motor tracts. We have, however, evidence which shows that each sense has its headquarters in some special part or parts of the brain. We must, nevertheless, bear in mind that no part of the brain is absolutely restricted to either motor or sensory nerves. We name the tract from the predominance of the nerves which end there, just as we call Paris a French city, although there is also dwelling in it a sprinkling of people from other nations.

The centre for sight lies in the occipital lobes, both on their exterior and mesial surfaces, and it sometimes extends as far up as the end of the fissure of Sylvius (see Fig. 7). When the cortex has been peeled off this part of a monkey's brain, the animal is blind. Injuries to this part of the human brain have resulted in more or less complete loss of sight. Investigations in this field have enabled us to distinguish between psychic and sensorial blindness. Psychic blindness is lack of recognition of an object that is actually seen. Thus, when the brain of a frog or a pigeon is removed, the animal may still see objects and avoid them when it moves. But the fact that such a pigeon has no fear of a cat or any other object shows that psychic blindness exists. Objects are seen, but not recognized. Sensorial blindness exists when no sensation from light is experienced. A Scotchman met with an accident that brought on him psychic blindness. He saw physically as well as ever, but he could not interpret what he saw. He would look at the most familiar objects and be utterly unable to recognize them. He would gaze at his New Testament without knowing what the object was until he ran his hand over the smooth cover, when he immediately recognized it. When a piece of detached bone, pressing on the centre for vision in his brain, was removed, he recovered his power of mentally interpreting what he saw.

Taste and smell are both probably located under the tip of the temporal lobe, in a convolution known by the name of either the hippocampal or uncinate gyrus (see Fig. 8). All the evidence for hearing points to its location in the rear two-thirds of the first and second temporal convolutions. When this lobe has been diseased, the patients have been more or less deaf or unable to understand what is said to them.

When we come to localize touch, we are met with peculiar difficulties, owing partly to almost innumerable tactile nerves which pour into the brain. Dr. Foster thus expresses the most probable conclusions reached, "The removal of a motor area, that, for instance, of the hand, entails not only loss of movement in the hand, but also loss or impairment of sensation in the hand. . . . So that the evidence seems con-

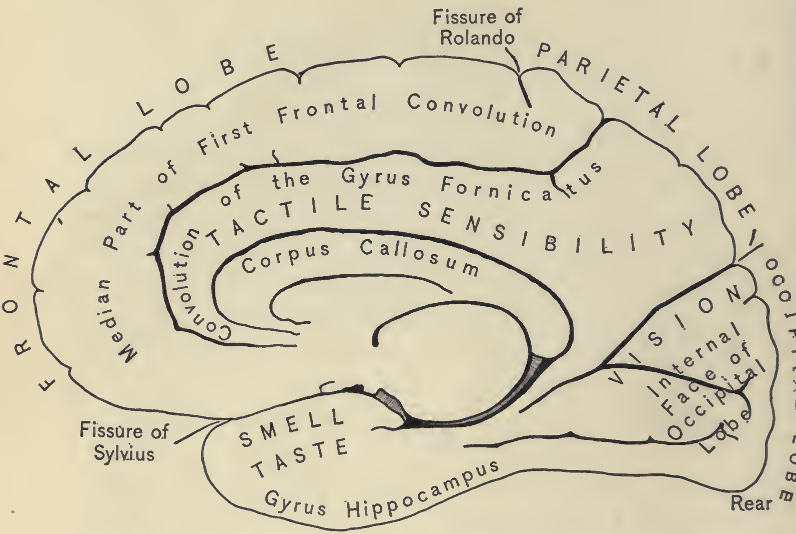

Fig. 8. — Localized sensory areas on mesial side of the right cerebral hemisphere, where it faces the left hemisphere.

vincing that the parietal region of the cortex, while it has special connections with voluntary movements, has at the same time special connections with cutaneous and other sensations. . . . Other observers, again, have found that in the monkey, removal or destruction of the gyrus fornicatus on the mesial surface of the brain . . . has brought the whole of the opposite side of the body to a condition which has been described as an anæsthesia, that is a loss of all cutaneous tactile sensations, and an analgesia, that is a loss of sensations of pain."[1]

After we have mapped out the brain to the extent of our ability, there yet remains the larger portion to which we can assign no definite function of any kind. Imagination, thought, emotion, and will have never been localized. No one has ever made it clear how mere brain cells can imagine or think. If we are to locate memory, thought, and feeling, at all, we must say that the entire brain is their organ. The spinal cord is certainly an organ of reflex memory. Thought must use the data supplied by all the senses localized in different parts of the brain. The phrenological folly of locating memory in any one "bump" or part of the brain is apparent. We have seen that the physical basis for the memory of sight is in the occipital lobe; of hearing, in the temporal; of smell and taste, probably in the gyrus hippocampus; of touch and general sensibility, in different parts of the brain; of motion, in various areas. When asked in what part of the brain memory is located, the proper reply is, "Memory of what? — of sight, sound, or some other sense; or of the motor function?"

We may sum up the question of cortical localization by saying hypothetically with Dr. M'Kendrick, "The frontal lobes appear to have to do with cognition and intellectual action. If so, the gray matter on the surface of the brain may be mapped out into three great areas, — an area concerned in cognitions and volitions in front, a motor or ideo-motor area in the middle, and a sensory area behind. These distinctions are no doubt arbitrary to a considerable extent; but if they are retained as the expressions of a working hypothesis, they are of service."

[1] Foster's *Text-book of Physiology*, pp. 799, 800.

We have by experimenting on the various sensory nerves learned some important facts about different brain tracts. Each sensory area reacts in terms of its own individuality upon any incoming stimuli. When a stimulus reaches the temporal lobes, there is a sensation of sound. If a like stimulus affects the occipital lobes, a sensation of light is experienced. If a stimulus like those which have caused sensations of light and sound is applied to the motor area of the arm, that will be moved. It will be noticed what powerful bearings these experiments have on the old-time metaphysical doctrines of realism. Professor Ladd says that Du Bois Reymond "showed that when a chain of four persons is arranged in such manner as to send a current of electricity through the tongue of one, the eyeball of another, and the muscles of a frog preparation held by two of the four, the same current will cause simultaneously an acid taste, a flash of light, and a movement of the animal's muscles."[1]

Each sensory brain area exists for the purpose of receiving the proper stimuli from the external world. These centres must remain comparatively undeveloped if they are not properly exercised. Our knowledge of localization enables us to appreciate more fully the important practical bearings of this passage from Drs. M'Kendrick and Snodgrass: "The sensorium does not act as a whole, but is differentiated, so that one part is devoted to one sense, another to another; and when the nerves which lead to these nerve centres have been stimulated, it matters not what the nature of the stimulus to the nerve has been, the sensation experienced is always for each centre of one and the same kind. Thus the optical centre always gives rise to the sensation of seeing something, the auditory nerve to that of hearing, the olfactory centre to

[1] Ladd's *Elements of Physiological Psychology*, p. 313.

sensations of smell, the gustatory centre to those of taste, and the tactile centre to touch."[1]

It should be noted that in mapping out the various convolutions and motor and sensory areas, we have been considering only the cortex or external covering of gray matter. This cortex, in which human consciousness is supposed to reside, is the extremely thin outer covering of the brain, varying from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch in thickness. Experts variously estimate the number of cells in this cortex at from one to two thousand millions. Hence we see that the most varied mental attainments may have a sufficient number of physical elements to accompany them. Professor Höffding rightly says, "When we reflect that any excitation works through the release of tension in organic cells, and that the result of this release in the individual cell may be connected in the cerebrum with results similarly obtained from millions of other cells, we grow giddy at the thought of the combinations which are possible."[2]

The interior of the brain is a mass of connective fibres. For the brain to act as a unit, all the convolutions and cells must be in more or less immediate connection.

We must now consider a third kind of localization, as important as either the motor or the sensory type. We may term this third kind *associational* localization. It is plain that if we see ourselves on the point of stepping into water or in danger of being run over, there must be, first, some means whereby the excitement in the retina can reach the cells in the occipital lobes; secondly, some way in which the tension in these cells can be communicated to the motor area for the leg; and, thirdly, a connection between these motor cells and our legs, which are to obey nervous impulses to move us out of harm's way.

[1] *Physiology of the Senses*, p. 2. [2] Höffding's *Outlines of Psychology*, p. 40.

The interior of the brain is a mass of connective nerve fibres. There are three kinds of these, — projection, commissural, and association fibres. The projection fibres *project*, so to speak, upon the cortex of the brain the results of sensory stimuli upon the body. The nearest figurative illustration that we can give of this action is the projection of a figure upon a screen by a

Fig. 9. — The projection fibres in the brain. — STARR.

magic lantern apparatus. Here the screen corresponds to the brain cortex; the rays of light on their way to the screen represent the sensory impulse in course of transmission by the fibres; and the picture on the screen stands for the result of the stimulus. Of course such an illustration is not literally true; but it has analogical truth, and it enables us to see the necessity for three different elements in each case. There are also motor projection fibres, which project the stimuli from certain motor areas upon the cells in the spinal cord, and thence indirectly upon the muscles. In this case, the muscles become the screen on which the motor cells focus their power.

In the above figure, *A* is placed on the projection fibres from the frontal lobes; *B*, on the fibres from the motor zone on either side of the fissure of Rolando; *C* represents the sensory tract for touch; *D*, the fibres leading from the optic nerves to the occipital lobes; *E*, the fibres from the auditory nerves extending to the temporal lobes. *K* indicates the place in the medulla oblongata where the fibres decussate or cross over to the opposite side. Hence the right leg would have its motor centre on the left hemisphere of the brain.

It will be noticed that the fibres in projecting themselves on the cortex of the brain spread out like a fan. Where they leave the skull they are obliged to contract into a bundle because of the narrow passage-ways.

We should endeavour to construct as definite images as we can of the physical accompaniments of mental action. If we do not, our ideas will be not only indistinct, but in a short time they will pass completely from the memory. We must remember that every stimulus of sufficient intensity is transmitted by the projection fibres of the special senses to the fitting tracts in the cortex of the brain. From the motor areas pass out projection fibres to the muscles throughout the body, whether to those controlling the vocal cords or a toe.

The commissural fibres are those which join like parts of the two hemispheres, and enable them to work in unison. For instance, there pass from the frontal lobes in the right hemisphere a set of fibres to the corresponding lobes in the left hemisphere.

We now come to the third class, the association fibres, the most important for the psychologist. These fibres connect different convolutions in the same hemisphere.

Were it not for the existence of these fibres, perception, memory, and thought would be impossible. Our perception of a pear is incomplete until we have fused into one mental

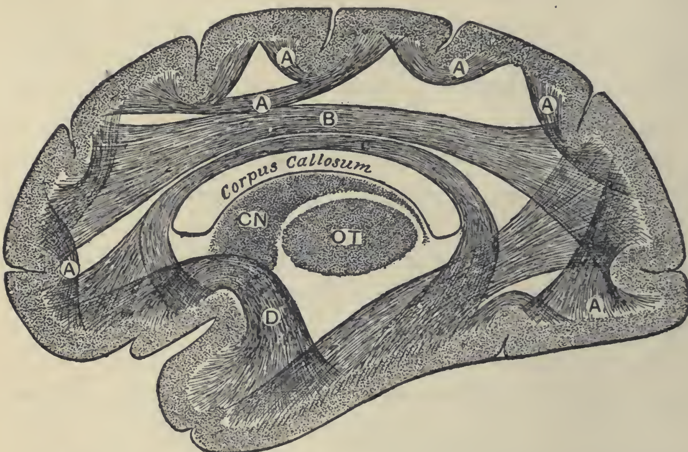

Fig. 10.—Side view of a hemisphere of the human brain, showing fibres associating the different tracts. "*A*, between adjacent convolutions; *B*, between frontal and occipital areas; *D*, between frontal and temporal areas; *CN*, caudate nucleus; *OT*, optic thalamus."—STARR.

whole the sensations from tasting, smelling, seeing, touching, and hearing the fruit fall from the tree. The optic nerves pour their stimuli into cells in one part of the brain; the auditory, tactile, gustatory, and olfactory, into still other parts. If there were no means of connecting these, the knowledge coming from the different senses could never be fused. The sensation from seeing a pear would be in one inaccessible territory by itself; that from tasting the fruit, in another. Memory would also be impossible, for here we proceed by association from one idea to another. The fibres furnish the physical basis of association. In thought, we need to have all our knowledge associated. In that peculiar form of brain injury which entails psychic or "soul" blindness, an object may be physically seen as well as ever, but such sight means nothing in the way of knowledge. A man in such a condition might see a precipice, and yet, failing to connect it with similar objects in the past, walk straight over the brink. We shall see later that these associative fibres probably increase in number as the individual grows older and connects his knowledge by thought relations. We see no reason for disagreeing with Dr. Flatau, who says: "The main function of the association fibres is probably psychical. They appear the most fitted to form the anatomical basis for the association processes of perception, thought, and will." [1]

Although the play of powers like imagination and thought may seem too airy to have any physical substrate, it is a proved fact that all forms of mental exercise produce a rise of cerebral temperature. Whenever we perceive a ruddy cloud or a blossoming orchard, whenever we experience a wave of feeling, build an air castle, or form a decision, up goes the temperature of the brain. A larger amount of blood goes to the grey matter of the brain than its weight would indicate. This excess is no more than enough to supply sufficient nutriment to restore the waste and wear involved in the peculiar work which the nerve cells are required to perform. Persons have been placed in a horizontal position on balances so accurate that a drop would incline them in either direction. If the persons began to think, or if their attention was called to anything, when the balance was in equilibrium, the head end would go

[1] Flatau's *Atlas of the Human Brain*, p. 25.

down. This movement would be due to increased blood in the brain. It has been proved that persons can lift more before than after mental labour. Brain work also requires more nourishing food than manual labour. During a portion of the period of writing a book, an author was at a summer resort where the food was poor and scanty. The part written there was so feeble in comparison with the other chapters, that he rewrote it in the autumn when he had better food.

The average weight of an adult male brain is about 49 ounces; of a female brain, 44 ounces. The weight of 278 male brains varied from 65 to 34 ounces; of 191 female brains, from 56 to 31 ounces. There is beyond doubt a general correspondence between a large and finely organized brain, on the one hand, and the intelligence, on the other; just as there is a general correspondence between a man's health and the amount of work he is able to accomplish. There have been stupid people with large brains, just as there have been sickly persons who have accomplished much. This fact does not lead us to conclude that a man's health has nothing to do with his success. Yet we must remember that fineness of structure, intricacy of convolution, and the development of the associative fibres have more to do with intelligence than mere brain weight.

It is interesting to notice the proportion of brain to bodily weight in some of the lower animals. The elephant's brain is $\frac{1}{500}$ of its body; the sheep's, $\frac{1}{351}$; the eagle's, $\frac{1}{160}$; the rat's, $\frac{1}{82}$. Contrast with these the ape's, $\frac{1}{29}$; the human infant's, $\frac{1}{7}$; children three years old, $\frac{1}{18}$; adults', $\frac{1}{45}$. An ox of 2000 pounds has a much smaller brain than a man weighing 120. In fact, a man's brain is absolutely larger than that of any other creature, excepting the elephant and the whale. An 11,200 pound whale had a brain weighing 60 ounces. The elephant's brain weighs from eight to ten pounds.

Now that we have drawn a rough map of the central nervous system and given our ideas something tangible to adhere to, we shall be better prepared to understand the following chapters.

CHAPTER II

Fatalistic Aspects

In discussing the training of the central nervous system, we are confronted at the outset by the assertions of some who say that we are just as powerless to improve the quality of our nerve cells as a tree is to change the character of its leaves or to alter its capillary circulation. These men will not accept the fact in rebuttal that persons have by the proper exercise actually improved their powers of nerve-discrimination, that a tea-taster, a hunter, a wool-sorter, a sailor, a musician, have actually trained their nerve cells to greater sensitiveness in certain directions.

The definition of the nervous system by fatalists is something like this: The nervous system is a machine bound to develop in accordance with its native potential capacities. All attempts of the individual to change or improve his nerves will prove utterly futile. He is like a watch that must run under conditions imposed by its own machinery. The watch must continue its necessitated movements until it runs down, or is stopped by some external cause.

Those of us who do not believe this must yet admit that the nervous system is a machine, the most wonderful known to us. The fatalists have reaped a great advantage from the unwillingness of many freedomists to admit this. Hence it seems wise, before proceeding further, to show how much of a machine the nervous system is. After we have established this fact, it should still be noted that we have not even then proved the general proposition: No machines are capable of improvement. After we have learned how much of a machine the nervous system is, we can proceed to train it more intelligently.

The machine characteristics appear most striking in the case of reflex action. Certain nerve cells have the power of reflecting a stimulus, brought by a sensory nerve, back along a motor nerve to produce a movement. A fly alighted on a sleeper's face and began to crawl over it. His hand was unconsciously raised to brush the fly away. The sensory stimulus from touch poured into a cell and flowed out along a motor nerve leading to the arm, which executed the movement proper in such a case. The fly persistently alighted three times, and was as often driven away by the fitting movement unconsciously made. The fourth time that the fly alighted, the brain action became sufficiently intense to awake the sleeper, who then sat up and endeavoured to kill the fly. The three preceding movements were unconscious reflexes, made with as much regularity as if the sleeper had been a machine operated by pressing a button.

The cortex of the brain is generally admitted to be the seat of consciousness. When stimuli cause the rest of the nervous system to act after the cerebral hemispheres have been removed, there is no dispute over the fact that such movements are due to the workings of a nervous machine and nothing more. The most interesting experiments on reflex action have been made on animals after the removal of the hemispheres of the cerebrum.

If we remove the brain from a frog and suspend him over some acid, so that his hind toes just touch the liquid, they will be withdrawn even more quickly than if the animal had its brain intact. Place the brainless frog on all fours, and put a a drop of the acid on his flank. The hind foot on that side is raised to brush the drop away. Amputate that leg, and after the reflex movements in the stump have proved ineffectual, the other leg will endeavour to remove the acid. Immediately after a French criminal had been beheaded, his pectoral muscle was pinched, and his hand was raised from his side to the muscle.

Removal of the brain from the lower animals almost invariably increases the reflexes until death ensues. That part of the nervous system that acts as deputy for the brain does its utmost to attend to all necessary work in such a case. While this attempt cannot be completely successful, it yet achieves some wonderful results.

Some animals after removal of the occipital lobes, or indeed, of the entire cerebrum, can see how to walk and avoid objects. Here, the rays of light affect the basal ganglia, or collections of nerve cells at the base of the brain, and without the intervention of consciousness enable the animal to change its course in walking so as to avoid obstacles. In illustration of this, Dr. Foster says: "Cases are recorded of the dog being obviously still guided in some measure by retinal impressions after the occipital lobes, and indeed the greater part of the brain, had been removed. . . . It is perhaps possible for simple afferent impulses to determine even complex movements without the intervention of 'consciousness,' and we may be justified in speaking of the effects of light on a brainless animal as being mere instances of 'mechanical' reflex action."[1]

When the cerebrum has been removed from pigeons and rabbits, the same general phenomena have been observed. Both animals in such a condition are remarkably perfect machines. Strange to say, these animals display more seeming spontaneity of movement than the brainless frog, but their higher intelligence is wanting. If placed in the room with a

[1] Foster's *Text-book of Physiology*, p. 793.

dog or a cat, they show no sign of fear, and they may even brush up against such an enemy. While the mere physical stimulation from light may so affect the nerve cells at the base of the brain as to cause the muscles to move with seeming intelligence, it must not be forgotten that the sight is merely physical, not psychical. In other words, while the sight of food, friend, or foe may cause the nerve cells to exercise astonishing control over the muscles, none of these objects are recognized. A brainless pigeon walking across the floor approached as close to a cat as to a pitcher.

After emphasizing the wonderfully complex machine movements of which some brainless animals are capable, it is well to note the limitations to such movements. If we carefully remove from a frog the cerebral hemispheres, leaving the cerebellum, medulla, and spinal cord, we can with careful treatment keep the animal alive for a considerable period, sometimes as long as a year. A chance observer might think that such a frog was normal. It can eat, swim, croak, and jump, avoiding obstacles in its path. This frog, however, differs in two important respects from those possessing the cerebral hemispheres. In the first place, it never moves unless acted upon by an external stimulus. Such frogs have been placed on a table and a chalk mark drawn around them. They have afterward been found dead without having stirred outside the mark. When they are thrown into the water, they continue to swim until they find something on which to rest or until they are exhausted. The action of the water upon the skin affords the requisite stimulus to develop the reflex act of swimming. Food might be lying near their mouths, but no attempts would be made to seize it. Before they could swallow it, some external agency must place it in their mouths.

In the second place, such frogs differ from a normal one in that the same movement invariably follows the same stimulus. In this respect they differ little from a machine; their movements can be foretold. No one can tell which of a number of movements a normal frog will choose in responding to the same stimulus. He may jump, when touched, or croak, or raise his foot to brush away the cause of the stimulus, or merely swell up. This shows that *consciousness*, together with the brain cells with which it is correlated, causes, even in the case of animals, movements so complex and varied that it is useless to try to foretell them.

A study of the foundations of will power along modern lines has certainly tended to show that many actions exhibit machine characteristics. Will deals with action, and at the threshold of all action lie reflex, instinctive, and impulsive nervous tendencies. The muscles of the eye are moved in an unconscious reflex way to cause the image of an object to be focussed on the most sensitive or yellow spot of the retina. When a candle is brought into a dark room, the eyes of an infant will naturally turn so that the image of the light will fall upon this yellow spot. If a bright coloured light is then brought in, the eyes of the infant will turn away from the candle and so adapt themselves as to have the image of the coloured light form upon the point of most distinct vision, no matter how much the light is moved about the room.

When the stimuli from cold affect the nervous system of the wild goose in a northern latitude, they develop action, and the bird flies to a warmer clime. When certain internal stimuli make themselves felt in the case of the caterpillar, it begins at once to weave its shroud. Prompted by such stimuli, the bird starts to build its nest; the human being, to mate, to search for a home, and to take up the round of domestic duties toward which his ancestors were likewise impelled. Blind impulses due to nervous tension have from the beginning of history driven men to do certain things. To-day such impulses cause a mother to shield her child, a panic-stricken army to flee, a young man to spend his patrimony in an illusory search for pleasure, a gypsy to wander from place to place.

In every idea there is a mechanical motor element, which displays itself either in nervous tension or in action. An idea of any concrete thing contains the germ of motor action. This will appear more evident when we come to consider the effect upon nerve cells of forming memory images of any kind (see Chap. XI.). If we image a ruddy peach or a cluster of purple grapes distinctly, there will be nervous tension developed which will pass into the retina and the muscles of the eye. A part of this tension may flow into the salivary glands, causing the mouth to water as one thinks of the luscious fruit. If we try to image distinctly a giant a mile high, standing a few rods in front of us, gesturing with his hand and scowling, we shall notice a tendency in the eyes to open more widely. The motor element affects the muscles controlling the lids. If the quoit thrower first images his action distinctly, the muscles will become more tense, and nearly the right energy to be used in throwing will thus be prepared to be liberated in them.

The motor element developed in every image furnishes the real reason why it is of such prime importance that children in the plastic age should associate only with those persons whom it will do no harm to imitate. One child cannot watch another rolling marbles without the development of the motor element in the idea, which often sets the second child to rolling marbles also. When we watch an athlete or a rope-walker at the circus, the motor element in our idea of his movements tends to develop in us incipient movements of the same kind. The fatal truth exists that the most of us must be imitators to a certain extent; few can be wholly leaders; but this truth is rendered less sad by the fact that we can also determine to a certain extent whom we shall imitate.

The curious process of muscle reading further emphasizes the motor element in ideas. C hides something, and B takes hold of him and walks off, apparently unguided, in search of the object. Perhaps no one would be more surprised than C if he was told that he was guiding B to the object. Muscle readers have said that the very best subject is the one who neither consciously helps nor hinders them; that he should simply keep his mind filled with the idea of the place. When B begins the search, he knows that C's ideas will be mirrored in his muscles. If C is taken in the wrong direction, the motor element in his idea of the right place will cause an involuntary contraction of his muscles. When the course is changed to the right one, the muscles immediately relax. B, with his skilfully developed touch, notices these signs unconsciously given. If he passes by the right place, he feels a contraction of the muscles, which warns him that he is going too far. When he comes to a row of shelves to which these muscular signs have led him, he must determine whether to reach for a high or a low shelf. He draws the subject's arm down and feels slight muscular contraction; he then directs the arm upward and notices that relaxation immediately develops, and so proceeds to find the article on an upper shelf. In the same way the number on any banknote can be written down by a blindfolded operator who holds the subject's hand, if the operator is allowed several tentative trials. If the first figure is a 6, and the operator starts to make a 7, he at once detects his mistake by the involuntary muscular resistance. If he starts with a downward stroke and then continuously moves the pencil to the right to make a 4, he again detects resistance. He now knows that the figure is either a 6 or a 1. To determine which, he begins a curve toward the right. If there is no resistance, he boldly declares 6 to be the first figure. Of course success in muscle reading demands cultivated tactile and muscular sensations, which notice movements imperceptible to the average person. The point to be observed is that the motor element in the idea unconsciously affects the nervous system and consequently our actions, and there is of course an element of machine fatalism in this. An extreme instance of this has been known in the case of a person who went to the roof of a tall building without a thought of suicide. He imaged himself jumping off, and the motor element in the idea affected his muscles so powerfully that he jumped and lost his life. Many persons seem to have an idea of the possibility of the sudden development of such an action against their will, and they rightly refuse to put themselves in any such dangerous position.

Hypnotism presents phenomena fully as remarkable as the case of the person whose image of jumping off the roof caused him to jump. Implant in a subject the idea that he is drinking vinegar, and the customary facial contortion will follow. Tell him that the sun is shining in his eyes and blinding him, and the motor element in the idea causes him to raise his hand to shield his eyes. Make him believe that he is lame, and he limps; that he is at a funeral, and down come the corners of his mouth; that he is walking on a hot surface, and he will hurriedly draw up his feet. No matter what idea is suggested to him, the motor element peculiar to it tends to rush out in the appropriate action.

We may concede the fact that the nervous systems of us all become by middle life largely machines, which react fatally in a given way when prompted by a certain stimulus. The person who in early life accustoms himself to say, "I laid down; he has set down; he come home last night; he drunk it all," will find that his organic motor memory will fatally retain these mistakes. He may learn later that such expressions are incorrect, but the motor cells controlling the organs of speech will discharge their energy as before. Not until *after* he has voiced the expression, will he realize that it is wrong.

This habituation of nerve matter to continue responding in the ways in which it has been early trained has its bright as well as its dark side. It is the purpose of this book to impress the fact that if the central nervous system is early habituated to make the proper definite responses, they will be perpetuated without any conscious effort on our part, and our minds will then be left free to engage in attending to higher things. A rightly trained nervous system will be like a watch-dog that guards our most prized acquisitions while we are asleep or awake, and while our own attention is directed elsewhere to enable us to climb the heights of knowledge. There may be an element of fatality about a rightly trained nervous system, and we are thankful that such is the case, just as thankful as when we secure a servant who can be depended on to do the right thing when we are not watching him.

We may now proceed to discuss another aspect of the question of fatality. We may be asked, as we recently were by an eminent man of science, "Do you contend that a man with a poorly organized brain could become a Shakspere? Do you maintain that a Mozart could have become a Raphael at will? Do you deny that the original construction of Mozart's brain rendered it absolutely pre-determined that he should become famous as a musician, if at all?"

Probably no person of sense to-day claims that a person can become anything he chooses. Certainly no one who understands a very little of the theory of heredity can make such a claim. The fox might like to become an eagle, and the Norman draft horse might wish to outstrip the Arabian courser, but the parentage and natural constitution of each forbid. All students admit that the circle of freedom is not infinite in extent. We are all sadly conscious of the fact that we are circumscribed. No being was ever allowed to choose its own parents; the fox was born such, so was the eagle, and the large clumsy horse; but there is nothing in that fact that renders improvement impossible for either the fox, the eagle, or the horse. No human being can defy the laws of his existence and organization; but although the circle of his freedom is small, it is large enough to require several lifetimes to develop to the fullest extent all his natural capacities. Along his own line, he can become a better or a worse man.

Probably Mozart was born with a remarkable auditory brain tract, with nerve cells of exquisite sensitiveness and complexity of interlacement. All the practice in the world would not make fifth-rate musicians out of some people, who are born without any natural capacity. The truth must also be emphasized that if Mozart's parents had sternly refused to allow him to have the proper musical training early in life, he would have failed to develop his temporal lobes to the limit of their capacity, and later in life he would have been compelled to work with a far less plastic brain. Thus, if the requisite means for training and developing the nervous system are not forthcoming early in life, even the possible genius may never develop a fraction of his earliest possibilities. In the same way, a person who might have been ordinarily successful in the walks of life may shrivel up into a nonentity because his latent capacities were not developed at the proper time.

It is by the light of such possibilities that one should read these statements of Professor Donaldson: "No amount of cultivation will give good growth where the nerve cells are few and ill-nourished, but careful culture can do much where there are those with strong inherent impulses towards development. On neurological grounds, therefore, nurture is to be considered of much less importance than nature, and in that sense the capacities that we most admire in persons worthy of remark are certainly inborn rather than made.

". . . Venn, studying the size of the head in Cambridge students, found it on the average greatest and growing for the longest time in the group of most successful men. The accomplishments of this fortunate group are therefore to be associated with innate capacities, and have small ethical significance; they may be admirable just as are the paces of a well-bred colt, but the colt deserves no credit for its gait." [1]

Professor James in one place in his excellent work, *The Principles of Psychology*, seems too much impressed with the fatalistic aspects of having a brain. He writes: "No amount of culture would seem capable of modifying a man's general retentiveness. This is a physiological quality, given once for all with his organization, and which he can never hope to change. It differs no doubt in disease and health; and it is a fact of observation that it is better in fresh and vigorous hours than when we are fagged or ill. We may say, then, that a man's native tenacity will fluctuate somewhat with his hygiene, and that whatever is good for his tone of health will also be good for his memory. We may even say that whatever amount of

[1] Donaldson's *The Growth of the Brain*, pp. 343, 350.

intellectual exercise is bracing to the general tone and nutrition of the brain will also be profitable to the general retentiveness. But more than this we cannot say; and this, it is obvious, is less than most people believe."[1]

Professor James proceeds at once to modify the fatalistic statements in the first two sentences quoted. Doctors say that a man can frequently improve his health, and, according to James, improvement in physiological retentiveness follows. He is also candid enough to give this personal testimony from a clergyman: "As for memory, mine has improved year by year, except when in ill-health, like a gymnast's muscle. Before twenty it took three or four days to commit an hour-long sermon; after twenty, two days, one day, half a day, and now one slow, analytic, very attentive or adhesive reading does it."[2]

We might suppose such a dialogue as this to take place between an extreme fatalist and a Tom Thumb:

"Mr. Fatalist, I should like to improve the muscles in my arms and trunk. They are weak and flabby. What exercise would you suggest?"

"Ah, Mr. Thumb, I perceive by your question that you have no conception of your unchangeable physiological muscular qualities, given you at birth. On hearing you ask such a question, one would naturally suppose that you thought that you could become a champion athlete like the late John L. Sullivan."

"Sir, you misunderstand me. I did not think to develop into a giant or a Hercules. I —"

"Training will do you no good, for your muscular system was given you at birth, and you can never change its potential capacities. No matter how wretched you make yourself with

[1] James' *Principles of Psychology*, Vol. I., pp. 663, 664. [2] *Ibid.*, p. 668

exercise, you will always be a Tom Thumb, whom any ordinary man could toss over a six-rail fence."

"Mr. Fatalist, I do not expect to become anybody else. I know I shall remain Tom Thumb, but it does not seem to me as if I were now more than half of what Tom Thumb is capable of being."

"You are all that your potential capacities will allow you to be. You were born a midget, and you are in nowise to blame for your lack of strength."

"But I can lift barely twenty pounds now without strain. Do you not think that if I exercised my muscles regularly, I could finally lift forty pounds?"

"Forty pounds! What do they amount to? I can lift two hundred without training."

"I think you can, but if I improve my muscles by exercise so that I can lift forty pounds, I am improving Tom Thumb just one hundred per cent."

"You fail entirely to catch the drift of my argument. It seems to me as if even a Tom Thumb ought not to be so stupid. Can you not see that I am merely insisting on the universality of cause and effect, and denying the freedom or power of any human will to change by its own effort anything a hair's breadth?"

"So the argument has reduced itself to the question of the freedom of the will! By the way, why did you use the word 'ought' when you said 'It seems as if even a Tom Thumb *ought* not to be so stupid?' But stop, that is not a fair question, for no one can be compelled to incriminate himself. I can only say that if I were to be thoroughly convinced that my will was no more free than a stone, instead of being able to lift twenty pounds, I could then lift only ten."

We may quote Dr. Ziehen to show the opinion of some physiological psychologists: "The processes of thinking are strictly necessitated. The condition of the cerebral cortex in any one moment necessarily follows from its condition in the preceding moment. . . . We cannot think as we *will*, but we *must* think as just those associations which happen to be present, prescribe. . . . This conception (of moral responsibility) is contradictory to the deductions of physiological psychology. The latter teaches that our actions are strictly necessitated; they are the necessary product of our sensations and ideas. Therefore, according to physiological psychology, we could no more hold a man guilty and accountable for his bad action than a flower for its ugliness."[1]

It is no more the business of this work to prove the freedom of the will than it is of every teacher of hygiene or temperance, or of any one who thinks that any power may be cultivated. If any one wishes to deny the testimony of consciousness in regard to freedom at one moment and at another to rely on the testimony of conscious reason to prove necessitarianism; if any one insists that we may as well abandon study unless we are guided by the rule that everything has a valid purpose, and then declines to give a satisfactory reason for our feeling remorse except on the supposition that we were free to act differently, — he may rest assured that it will be a long time before human beings eliminate from their vocabulary such words as obligation, morality, crime, foolishness, remorse, or effort.

There is, however, very serious harm done by those who talk extreme fatalism. The mere belief that we can do a thing becomes an extra cog in the motor power applied to move our wheel of progress. There is nothing more palsying than doubt and unbelief. They fall like a frost upon budding human effort. Since the times of which Virgil sang, many a man has been able

[1] Ziehen's *Introduction to Physiological Psychology*, pp. 188, 216, 270.

to do a certain thing because he thought he was able. The Elizabethans believed that the growth of learning and the wonders of the New World would open the gate to Eden. Hopefully these sixteenth century enthusiasts laboured to find it, and as a result of the spirit of that age we have Shakspere.

Guyau thus forcibly presents these aspects of the case: "When we say to a (hypnotized) subject, 'you cannot move your arm,' we paralyze the motor current that sets the arm in motion. Hence I think we can establish the following law: Every manifestation of muscular or sensorial activity does not take effect unless accompanied by a certain belief in one's self, or by the expectation of a determinate result, on the occurrence of certain antecedent conditions. The consciousness of action is thus partly reduced to the belief that one is acting, and if this belief is destroyed, the consciousness itself becomes disorganized. All conscious life is based on a certain self-confidence. . . . Suggestion is the introduction within us of a *practical belief* which is spontaneously realized; the moral art of suggestion may, therefore, be defined as *the art of modifying an individual by persuading him that he is, or may be, other than he is.* This art is one of the most important appliances in education. All education, indeed, should be directed to this end, to convince the child that he is *capable of good and incapable of evil,* in order to render him actually so; to persuade him that he has a strong will, in order to give him strength of will; to make him believe that he is morally free and master of himself, in order that the idea of moral liberty may tend to progressively realize itself."[1]

We certainly have sound reasons for believing that we can by the proper training make our nervous systems more helpful machines. It is probably a fact that the number of cells in the

[1] Guyau's *Education and Heredity*, pp. 22–24.

brain is determined at birth, and that no training will increase this number. We, however, fail to see why it is necessary to increase them. We might as well argue that it is hopeless for any one desirous of becoming a runner to exercise the muscles in his legs because the number of his legs is absolutely determined at birth, and is subject to no increase. There are between one and two thousand million cells in the brain, and there was probably never a person who did not have several million undeveloped ones.

Two gardeners may till precisely the same patch of ground, — the one after the other. The second gardener may, without increasing the extent of the patch one foot, double the amount of the yield. The ground may be fit for producing nothing but cabbages, and yet he may raise cabbage heads twice as large as those grown by the first tiller. Two pups may be taken from the same litter, and the central nervous system of the one be trained to respond promptly to the word of command. This training will form actual grooves in the brain, and the nerve cells will discharge their energy definitely and reliably — in other words, habitually — when the proper stimulus is felt. Such a dog cannot be dispensed with in hunting, and he is valuable in guarding property; whereas his untrained brother cannot be depended on in any capacity. The same thing is true of children. They may be trained so as to respond in the right way to any duty in life. If they see a misplaced article, they may, on catching sight of it, put it in its place as naturally as a dog points toward the bird for which the hunter is looking. If they resolve to do a thing, the motor centres in their brain, trained by fitting early exercise, will be better adapted for initiating the proper movements.

It is an old saying that one cannot make a silk purse out of a sow's ear. Another proverb supplementary to this ought to become current, — that both the quality of the sow and of her ear may be improved. In the last century a persistent English farmer so improved his breed of sheep that each yielded twice as many pounds of better mutton than before. The late Professor Maurice was asked why he taught certain classes special subjects with such painstaking effort, when the majority would become nothing but hewers of wood and drawers of water. He replied that he feared, if he did not do his utmost in the way of instruction, that the wood would be badly hewed, and the water spilled in the drawing.

After a number of years' experiment with the growing nervous system of youth, the writer has demonstrated to his own satisfaction that young nerve cells are more amenable to training than any other matter of which he has knowledge. He is pleased to quote some recognized authorities on this point. Professor Donaldson says: "It has been made probable that by the cultivating processes of school training the formed structures tend to be strengthened, dormant elements roused to further growth and organization, and made more perfect in this or that direction according to the nature of the exercise. By strengthening the formed cells their powers of differential reaction, of organic memory, and resistance to fatigue are increased. By associating given sets of muscular reactions with given sense impressions, habits are formed. . . .

"It must be remembered that, as a rule, our latent capacities as individuals are far beyond our regular achievements, and that the stimuli which shall bring these powers into action may be of very different sorts."[1]

The united testimony of two eminent physicians may also strengthen the reader in his belief that the wonderfully plastic nervous system is subject to improvement. They thus con-

[1] *The Growth of the Brain*, pp. 344, 360.

clude one of their works: "The degree of excitability of the nerve centres varies considerably among individuals, and it also may be influenced by exercise. On this depends the *aptitude* for reflex acts of all kinds. Lastly, there may be a greater or less influence exerted by the higher over the lower centres; or, in other words, a greater or less degree of inhibitory power. The power of the *will*, which may also be strengthened by exercise, or weakened by yielding to disease, or by tame compliance, depends on this factor. Thus by a study of nervous actions, as connected with and stimulated by impressions on the organs of sense, we have constructed a *physiological basis of character*, and that without admitting the truth of an exclusively materialistic hypothesis. Behind all brain action, although closely connected with it, there is the strongest probability of the existence of an immaterial agent of which Spenser wrote in his *Hymn in Honour of Beauty:*

> "'For of the soul the body form doth take,
> For soul is form, and doth the body make.'"[1]

[1] M'Kendrick and Snodgrass, *Physiology of the Senses*, p. 297.

CHAPTER III

THE POSSIBLE MODIFICATIONS OF THE BRAIN

IT is rightly inferred that training can make some change in the brain. The question is therefore pertinent: How can the brain be modified? To this a definite reply ought to be forthcoming.

Exercise can modify the brain in at least three different ways: I. The sensory brain tracts may be modified by incoming currents from the different senses. II. The motor areas undergo change from initiating new muscular movements and from often repeating old ones. III. The modification of the associative functions of the brain is of special importance.

When the sensory portions of the brains of the deaf and dumb have been carefully examined, they have shown a lack of development in the cortical areas of the lost senses. Professor Donaldson made a careful study of the brain of Laura Bridgman[1] after death, and discovered some facts from which important deductions can be drawn for the training of the central nervous system. Laura Bridgman was born in 1829 and died in 1889. She had the use of all her senses until she was nearly three years old, when she had a severe attack of scarlet fever, which made her completely deaf and deprived her of sight in her left eye. She could see a trifle with her right eye until she reached her eighth year, when she became stone blind.

[1] See *American Journal of Psychology*, Vol. III., No. 3; Vol. IV., Nos. 2 and 4.

Professor Donaldson examined fourteen localities in each hemisphere, and found that the cortex of her brain was thinner than the average. He says: "In this connection it is interesting to notice that those parts of the cortex which, according to the current view, were to be associated with the defective sense organs, were also particularly thin. The cause of this thinness was found to be due, at least in part, to the small size of the nerve cells there present. Not only were the large and medium-sized nerve cells smaller, but the impression made on the observer was that they were also less numerous than in the normal cortex." He also found that the cortex of the right occipital region was much thinner than the left. This region was the principal cortical centre for the left eye, in which sight was the earlier lost. It is a reasonable inference that the left occipital lobe was the better developed because sensory stimuli from the right eye poured into it the longer. These helped to modify and develop the brain cells there.

When we speak of undeveloped potentialities, it is well to remember Professor Donaldson's conclusions that "at birth, and for a long time after, many systems contain cell elements which are more or less immature, not forming a functional part of the tissue, and yet under some conditions capable of further development. . . .

"For the cells continually appearing in the developing cortex no other source is known than the nuclei or granules found there in its earliest stages. These elements are metamorphosed neuroblasts which have shrunken to a volume less than that which they had at first, and which remain small until, in the subsequent process of enlargement necessary for their full development, they expand into well-marked cells. Elements intermediate between these granules and the fully developed cells are always found, even in mature brains, and therefore it is inferred that the latter are derived from the former. The appearances there lead also to the conclusions that many elements stop short of complete development, and that the number which might develop in any given case is far beyond the number that actually does so, and that the characteristic appearance of the cortex in the various localities depends on the expansion of dissimilar layers of the primitive granules." [1]

It is probable that if we had microscopes of sufficient magnifying power, and if we could also expose without injury the brains of growing children for frequent inspection, we should see the cells of the various sensory areas in course of modification. We should probably also see these cells developed and refined in proportion as the child was taught to exercise his senses sufficiently and judiciously upon the right material. We might further expect to see the modifications due to development retarded so long as the child could not have interesting objects to appeal to all his senses. Could we have watched the temporal lobes of Beethoven and Mozart, we should probably have seen cellular development there as musical sounds poured into their ears and affected those lobes.

When barbaric man received any news at second hand, that is, not through the media of his own senses, the information almost invariably reached him through the ear, and the modification which the temporal lobes thereby received is still shown in some striking ways.

A teacher thus records his actual experience with the ear and eye interpretation of a class of boys of the average age of fourteen, engaged in reading Shakspere's *As You Like It*. We give the account, together with an illustrative passage in full, because experience is preferable to any amount of theorizing. This account ought to enable us to understand better the

[1] Donaldson's *The Growth of the Brain*, pp. 74, 238.

necessity of taking advantage of existing brain modification in teaching pupils to grasp certain subjects more fully.

"I had a class of about thirty boys, of the average age of fourteen, reading Shakspere's *As You Like It*. For a while I read the advance lesson to them the day before, sometimes not explaining a single passage. They showed such intelligent

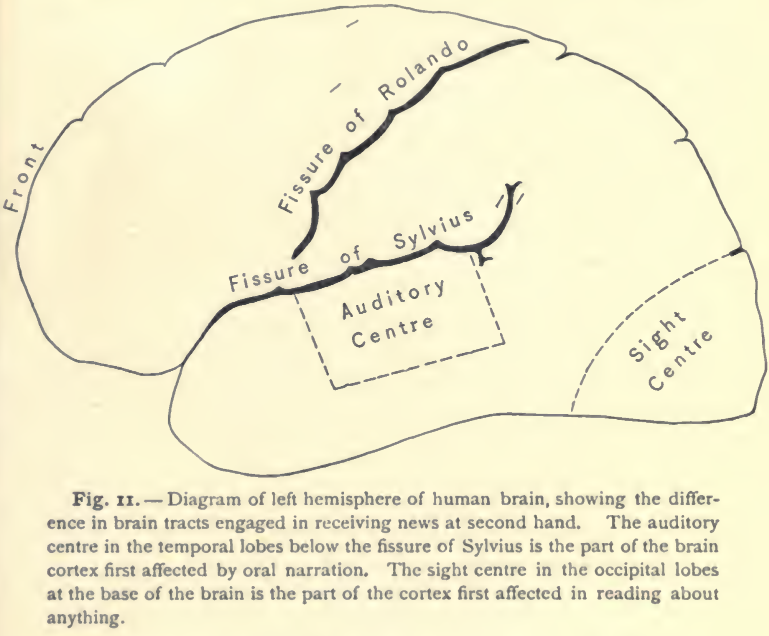

Fig. 11. — Diagram of left hemisphere of human brain, showing the difference in brain tracts engaged in receiving news at second hand. The auditory centre in the temporal lobes below the fissure of Sylvius is the part of the brain cortex first affected by oral narration. The sight centre in the occipital lobes at the base of the brain is the part of the cortex first affected in reading about anything.

appreciation of the story that I concluded it was not necessary for me to waste any more time in reading the advance lesson, and so devoted my time to having them give me the story of the lesson for that day, and what they thought of the characters and the situations. I noticed that the recitations at once became poorer, and the interest seemed to decline. After a few days I scolded the class sharply, but as the next lesson was no better, I again reprimanded them. Some of the boys asked me to read the lesson, saying that they understood it better when I did.

"Thinking that this was a ruse to kill time and keep from answering questions, I replied that the English in the passage which they seemed not to understand was nearly as easy as a third reader lesson, and that they could read such easy English just as well as I, if they were not too lazy. I was surprised to hear the brightest boy in the class — and he was, indeed, remarkably bright — say, 'When we look at the printed words, they don't seem to mean as much as when we hear you read them. Things seem to branch out more then, and I can somehow seem to hear the characters talk afterwards.' 'Yes, sir; yes, sir,' echoed a number of other boys, 'that's so.'

"'You have failed to comprehend this passage, one of the finest in the play,' I said, feeling that I was the victim of a conspiracy. 'Close your books, and I will now read this passage to you without a word of explanation. I shall hold you responsible for telling me what there is difficult about it.'

"I then read slowly:

> *Oliver.* Orlando doth commend him to you both,
> And to that youth he calls his Rosalind
> He sends this bloody napkin. Are you he?
> *Rosalind.* I am! What must we understand by this?
> *Oliver.* Some of my shame; if you will know of me
> What man I am, and how, and why, and where
> This handkercher was stain'd.
> *Celia.* I pray you, tell it.
> *Oliver.* When last the young Orlando parted from you
> He left a promise to return again
> Within an hour, and pacing through the forest,
> Chewing the food of sweet and bitter fancy,

Lo, what befel! he threw his eye aside,
And mark what object did present itself:
Under an oak, whose boughs were moss'd with age
And high top bald with dry antiquity,
A wretched, ragged man, o'ergrown with hair,
Lay sleeping on his back! about his neck
A green and gilded snake had wreathed itself,
Who with her head nimble in threats approached
The opening of his mouth; but suddenly,
Seeing Orlando, it unlink'd itself,
And with indented glides did slip away
Into a bush: under which bush's shade
A lioness, with udders all drawn dry,
Lay couching, head on ground, with catlike watch,
When that the sleeping man should stir; for 'tis
The royal disposition of that beast
To prey on nothing that doth seem as dead
This seen, Orlando did approach the man
And found it was his brother, his elder brother.

Celia. O, I have heard him speak of that same brother;
And he did render him the most unnatural
That lived amongst men.

Oliver. And well he might do so
For well I know he was unnatural.

Rosalind. But, to Orlando: did he leave him there,
Food to the suck'd and hungry lioness?

Oliver. Twice did he turn his back and purposed so;
But kindness, nobler ever than revenge,
And nature stronger than his just occasion,
Made him give battle to the lioness,
Who quickly fell before him: in which hurtling
From miserable slumber I awaked.

Celia. Are you his brother?

Rosalind. Was't you he rescued?

Celia. Was't you that did so oft contrive to kill him?

Oliver. 'Twas I; but 'tis not I.

"'Now tell me what there is difficult about that,' I said, after finishing the passage.

"'Nothing,' echoed a dozen voices.

"I noticed that some of the speakers were those who had failed to understand the scene or to give me a clear idea of Orlando's nobility or to point out the exact signs of returning manhood in Oliver. 'You may rise and give me the story contained in this passage, and then tell me what it suggests to you,' I said to one of the boys, who had a few minutes before failed to answer the same question.

"He now rose and gave in his own words an account of the passage, and then described the moral lesson which it taught. He did so well that I said promptly, 'Why did you not read this yourself before coming into the class?'

"'I did, sir, but it seemed hazy to me. It didn't seem to branch out as it did when you read it.'"

After this the teacher read the advance lesson to the class, and obtained far better results. For untold barbaric ages, man had obtained, through the medium of the ear, almost all the knowledge that came to him second hand. The newspaper and the book did not exist for him to interpret their meaning by the eye.

It is easy enough to say that some boys are naturally of the auditory type, others of the visual, but this does not explain away such cases as the preceding; for, in a certain sense, the majority of the class were visualists; that is, they could recall sights better than sounds. But more accurate investigation of the facts showed that even the visualists could construct a more vivid visual picture if the elements were given them through the ear rather than through the eye. By glancing back at the passage quoted from *As You Like It*, we shall notice that the greater part of that special passage requires visual, not auditory, interpretation. The oak, ragged man, green and gilded snake, and lioness appeal more powerfully to the eye than to the ear; but they excite the visual tract most strongly when it is awakened through associations that come by way of the ear.

Those schoolboys, therefore, visualists as well as others, retained that auditory brain modification from primeval times, and so were able to interpret past events better by hearing them told than by seeing them described on the printed page. The writer never thinks of the experience of that class in *As You Like It*, without remembering the case of a dog who was watching for the return of his master. When the master appeared within the range of distinct vision, the dog looked dreamily in that direction, but failed to recognize him. A few seconds later a puff of wind came from the direction of the master toward the dog, and the animal immediately sprang off to meet him. The dog had seen the master, but the affection of the retina and the occipital lobes meant nothing to the animal. "The sight of the master did not branch out," as the schoolboy said. The dog's olfactory tract had been his chief interpretative agent for ages, hence the moment the wind brought a whiff of the master's odour, he was recognized.

We must remember, then, that the brain is subject to modifications from each of the senses. After receiving a new sensation, the brain of the infant is a changed organ, and it will thereafter react in a changed manner upon the world's stimuli.

Next, we pass on to motor modification. We have seen (Fig. 6, p. 14) that the motor area for the brain lies on both sides of the fissure of Rolando, and that every muscle in the body is under the more or less direct control of motor cells somewhere in the central nervous system. The infant modifies his motor cells by each new movement, or combination of movements, that he makes. He also renders this modification more definite and permanent by repeating those same movements.

The process of modifying the cells at the top of the fissure of Rolando, which initiate and control movements in the leg, begins soon after birth. When the infant flexes or extends his legs, wriggles his toes, or kicks, his motor cells have begun that process of modification which will finally enable them to control the legs in the wonderful art of walking and keeping the body in equilibrium on two feet. The player on the piano or the violin spends years in modifying the motor cells controlling the arm and hand in order to secure movements exactly fitted to the requirements of the case. In learning how to write, almost every one has hard work so to modify the motor cells that they shall guide the pen only where he wishes it to go. Most of us have memories of our pens going into outlandish places while we were trying to make a letter like the copy. Every man of action in any field is engaged in modifying his motor cells.

Whether we are speaking of motor or sensory cells, we may agree with Delbœuf, who says: "Every impression leaves a certain ineffaceable trace; that is to say, the molecules, once they are arranged otherwise and forced to vibrate in a different way, will not return exactly to their original state. If I brush the surface of still water with a feather, the liquid will not resume the form which it had before: it may again present a smooth surface, but molecules will have changed places, and a sufficiently penetrating eye would certainly discover therein evidence of the passage of the feather. Animal molecules that have been disarranged have thereby gained, in a greater or less degree, the capacity for undergoing disarrangement. Doubtless, if this same external agency does not again act anew upon the same molecules, they will tend to resume their own natural movement; but the case will be very different if they are again and again subjected to the same action. Then they will little by little lose the power of returning to their natural movement and will become more and more identified with that which is impressed upon them, till at last it becomes natural to them in its turn, and they obey the slightest cause that will set them in vibration."[1]

If we could examine the developing motor region with a microscope of sufficient magnifying power, it is conceivable that we might learn wherein the modification due to exercise consists. We might also, under such conditions, be able to say, "This is the motor region of a piano player. The modifications here correspond precisely to those necessary for controlling such movements of the hand"; or, "This is the motor tract of a blacksmith; this, of an engraver; and these must be cells which govern the vocal organs of an orator."

While we shall probably have neither the microscope, nor the opportunity to use it in any such way as this, we are nevertheless sure that modification of the motor area changes the correlated muscular reaction. Pathology has rendered that conclusion certain. Cases of brain tumours, epilepsy, and paralysis have demonstrated the fact beyond question.

The cortex of the brain is modified in a marked manner by the development of fibres of association (see Fig. 10, p. 24). Vulpius made a very careful study of the tangential fibres, which run parallel to the surface of the cortex and connect various convolutions with each other. These fibres are, of course, as important to the brain as good wagon roads, canals, and railroads are in the development of a country. Vulpius found that between the ages of sixteen months and thirty-three

[1] Delbœuf, quoted by Ribot, *Diseases of Memory*, Chap. I.

years the number of these fibres had increased. The following charts will show the rate and duration of this increase.

In the third left frontal convolution (see p. 11), which is the motor area for speech in case of right-handed people, Vulpius found that the fibres increased steadily in number until the age of thirty-three. This number remained approximately the same until fifty. (See Chart C, p. 57.)

The ascending frontal convolution (see p. 11), which is a varied motor centre, likewise showed an increase up to the age of thirty-three. In old age these fibres show a very striking decrease. This decrease might have been expected from the waning powers of athletes after early maturity. (See Chart D, p. 57.)

The first temporal convolution (see p. 11) also increased its fibres up to the age of thirty-three. This convolution forms part of the sensory centre for hearing. The fibres here show no increase after thirty-three, but the decrease probably comes late. (See Chart E, p. 57.)

The existence of these associative fibres is absolutely essential for memory, association, and motor discharge. We have already seen that the various sensory nerves pour their currents into different parts of the brain cortex. Unless these were associated, we could not fuse into one idea for future recall the various sense aspects of the same thing. Thus, an orange seen would not be the same to conscious memory as an orange tasted. A rose smelled would never be the same as a rose touched. Again, the sight of a rose could never be an incentive for us to pluck it, unless there were fibres connecting the area for sight with the motor centre for the arm. We might see a runaway horse dashing toward us, but the sight stimulus would not impel us to get out of the way, unless fibres ran from the occipital lobes to the motor centre for the legs.

A scholarly gentleman, who was an excellent logical talker,

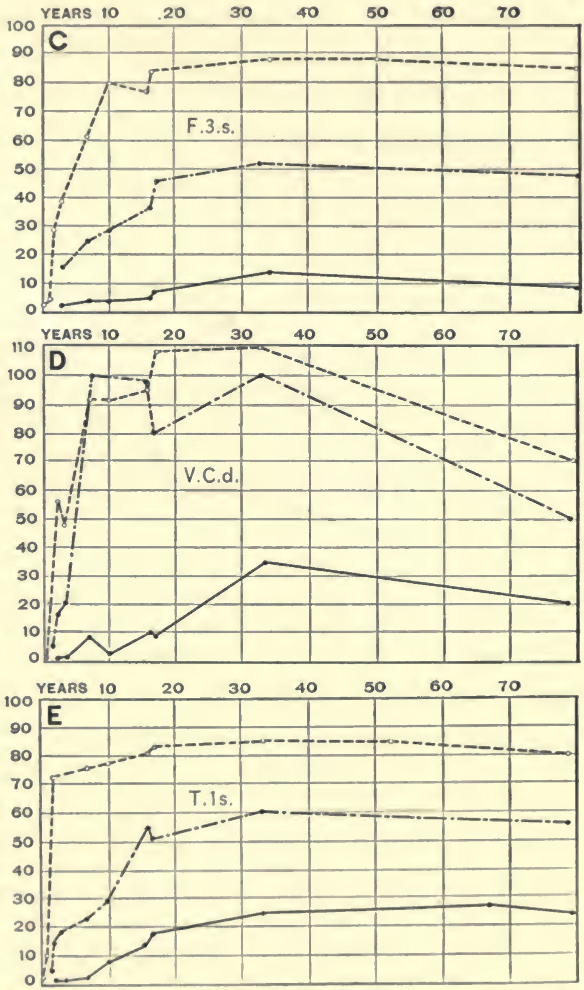

Fig. 12.—Charts C, D, E, to show the increase and decrease in medullated associative brain fibres from the outer, inner, and interior layers of the cortex. The dashes - - - - - - indicate the outer layer; the unbroken line, the middle layer; the line broken by dots, the inner layer. The figures on the top

represent the age of the person examined; those on the left side against the vertical, the average number of fibres in 0.036 square mm. of surface. Chart C is for the third left frontal convolution; D, for the right ascending frontal convolution; E, for the left first temporal convolution. — DONALDSON, from VULPIUS.

complained that, when he sat down to write, his ideas fled; if he began to talk on the same subject, their sequence was easy and rapid. For years he had trained his ideas to seek an

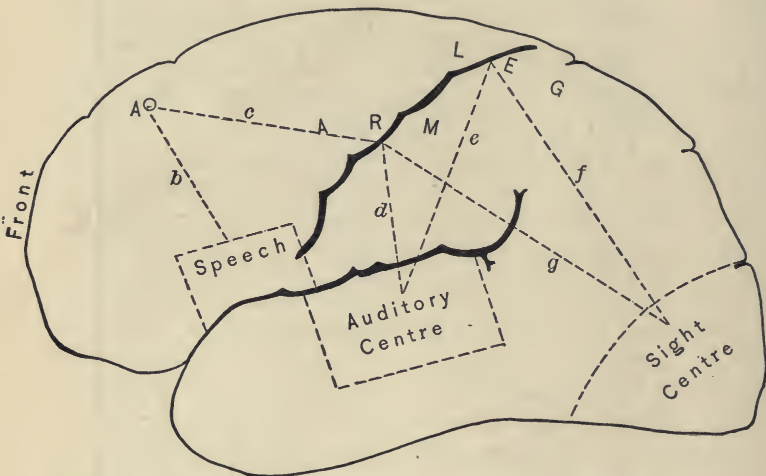

Fig. 13. — Diagram to illustrate some of the association paths in the brain.

outlet through the motor centre for speech, and not through the motor cells which directed the movements of the pen in writing the thoughts. A diagram illustrating this difference of outlet will enable us to see more clearly the necessity for brain modification by different associated paths.

Let us suppose that *A* is an idea correlated with a portion of the frontal lobe of the brain. In the case of the gentleman already mentioned, the habitual outlet for the expression of the idea had been along the path *b* leading to the motor centre for speech. When he wished to write, the outlet was along the strange path *c* to the motor centre for the arm. Just as some roads in a forest become impassable or ill-defined for want of travel and attention, so the gentleman found the path *c* well-nigh impassable for his idea. Because of natural inaptitude or lack of early training, or both combined, Washington Irving could scarcely make a presentable speech one minute in length on any public occasion. In his case the path *c* toward expressing his ideas by writing was easy, but *b* was a way very hard to travel.

When a soldier marching hears the command "Halt!" the tension developed thereby in the auditory centre passes along the path *e* to the motor centre for the legs, and he inhibits their movements. If he hears the command "Carry arms!" the tension passes from the auditory centre along the path *d* to the motor centre for the arm.

If the engineer of a locomotive plunging ahead in the darkness were to see a red light, the tension in the sight centre from such a stimulus would pass immediately by the path *g* to the arm centre, and the throttle-valve and air brake would be pulled. If we saw some one about to step on our toe, the stimulus due to this would pass rapidly by the path *f* to the leg centre, and an effort would be made to withdraw the foot in time.

We can now understand why an increase in the number of brain cells is not so important for the manifestations of genius as is the establishing of connections between different cells. Genius enables a man to see an old fact in a new light or a new fact in an old light. Common eyes had, since the earliest times, seen the steam escaping from a boiling vessel. Finally, the eyes of a genius associated that vapour with the strength of a horse, and the manner of life of the entire world has in consequence been changed. A genius concluded that the moon must be held in her orbit by some natural law, and he straightway proceeded to associate this new induction with the old phenomenon of the fall of an apple or the fact that a basket containing apples could be revolved at such a rate of speed that the apples would not fall out when the basket was inverted. Whenever new brain cells are associated, there comes into existence a physical basis for a new idea in the world of thought. There has been no increase in the number of letters in our alphabet for a very long time, and yet the possible combinations are such that the increase in words since even Dr. Samuel Johnson's day is something enormous. We can now readily understand why the brain of a genius and of an ordinary person may be of nearly the same weight. The proportion of isolated and comparatively worthless cells would be far greater in the case of the ordinary man.

A study of the central nervous systems of children and adults has shown that the brain and spinal cord are modified in respect to both weight and size with advancing years. The brain weight is more than three times greater at maturity than at birth, while the spinal cord is seven and one-half times heavier.

To recapitulate, we may say that each sensory brain tract is modified by exercise. Every time the song of a bird is heard, a flower is seen, a rose is smelled, a door-knob is touched, a fruit is tasted, or a pound weight is lifted, the corresponding sensory brain tract is thereby modified. Whenever the fingers are flexed, an arm extended, the muscles of a leg moved, the body bent, the expression of the face changed, or a word spoken, there is a corresponding motor modification in the brain. From birth until the age of thirty-three there is an increase in the cerebral association fibres. During this period the central nervous system is also modified in respect to size and weight.

CHAPTER IV

Attention, Nutrition, and Fatigue in their Relations to the Central Nervous System

On the physical side, we may define attention as tension in nerve cells. There is an analogy between cells which are at any time furnishing the physical basis of attention, and the tense strings of an Æolian harp, which are vibrating in the wind with sufficient intensity to produce a sound.

It is usual to distinguish between reflex and voluntary attention. Reflex attention is given, without our seeking or volition, to certain incoming nerve stimuli of great intensity or peculiar quality. The discharge of a cannon, the slamming of a door, the tumbling of a clock off the mantelpiece, a flash of lightning, the odour of onions or of boiling codfish, the unsuspected pepper in the First of April candy, or a rude slap on the back, will sufficiently stimulate the auditory, visual, olfactory, gustatory, or tactile centre in the brain to cause attention even against our will. In reflex attention there is lack of previous voluntary innervation in the appropriate centre. The stimulus comes when we are not looking for it.

In voluntary attention, on the other hand, we are conscious of an effort to make the utmost out of the object, whether subjective or objective. When we are listening for an approaching footstep, it is probable that the voluntary attention centred in that direction serves to make more sensitive to sound certain brain cells in the auditory centre. It is certain that we can hear sounds inaudible to another, if we are already on the attentive watch for them. We can explain this on no other ground than that voluntary attention is correlated with heightened activity in the proper cortical brain area, and that this activity is developed in advance of an incoming sensory stimulus. Common experience teaches us that we may hear a faint tap on our door, if we are expecting a caller, but if we are busy with some interesting work, loud knocks may be necessary to call forth reflex attention.

A knowledge of the fact that attention of any kind is correlated with expenditure of energy in nerve cells is of the utmost importance in any branch of education. The majority of parents and teachers have been singularly neglectful of the physical accompaniments of attention. Their importance will be manifest when one realizes that without these there can be no attention of any kind. Even reflex attention will exhaust nerve energy in certain brain tracts if the stimulus is continuous. Boiler-makers are sometimes thankful for this, although not for the increasing difficulty of hearing, which is the usual accompaniment of such continued over-stimulation of the auditory centre.

Voluntary attention makes severer drafts upon the brain than reflex attention. Tense voluntary attention will weary the strongest brain, which will soon demand rest or a change in the direction of attention. Let any one extend his arm as tensely as possible and hold it at right angles to his body. This muscular tension will soon cause weariness. In an analogous way, tension in brain cells soon exhausts their energy for a while. Just as a change of position will enable the arm to do additional work, so a change of subject, involving a different direction to the attention, will admit of additional voluntary mental effort. Indeed, this often seems more restful than mere vacuity of attention.

Not only mental effort, but work of any kind, tends to use up the stored energy in nerve cells and to bring on fatigue. Hodge stimulated by electricity the nerves leading to the spinal ganglion cells of a cat. The stimulus was continued for fifteen seconds and then intermitted for forty-five seconds. During the hour there was a total of twenty minutes stimulation and forty minutes rest. At the end of one hour, the nuclei of the stimulated cells had shrunk twenty-two per cent. After a period of sufficient rest, which would vary with the age of the animal, the nuclei regained their normal size. In some cases, after a severe stimulation for five hours, Hodge found the volume of the nucleus diminished fifty per cent. He killed certain animals in the evening after a day of activity, and compared the size of the cells with those of animals of the same species killed in the morning after a night of repose. The cells of the latter animals were found to be the larger. Fresh proof was thus obtained that the nervous system demands recuperative rest after activity.[1]

Muscular activity and the ensuing fatigue are correlated much more closely with fatigue in the central nerve cells than is popularly thought. Professor Donaldson says: "In the last stages of extreme fatigue, it is the nerve cells, not the muscles, which are exhausted. . . .

"In general, the fatigue which controls us is in so large a measure dependent on the nervous system that there is reason to make the changes occurring there the most prominent, though it can also be shown that the glands and muscles undergo changes as the result of activity."[2]

Seeing, then, that muscular energy is so closely associated with the condition of the nerve cells, all influences affecting

[1] Hodge, *Journal of Morphology*, 1894.
[2] *The Growth of the Brain*, pp. 312, 322.

them are of extreme importance whether for mental or physical work. Lombard ascertained by experiment that the energy in the muscles, and consequently also in the central cells,

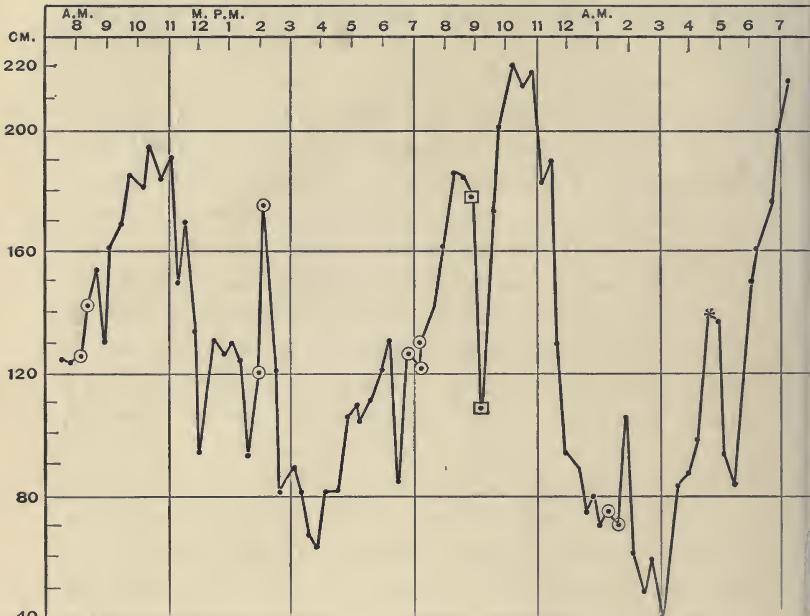

Fig. 14. — "Showing at each hour of the day and night how many centimeters a weight of 3,000 grammes could be raised by repeated voluntary contractions of the forefinger before fatigue set in. The curve is highest at 10 to 11 A.M., and 10 to 11 P.M. Lowest, 3 to 4 P.M., and 3 to 4 A.M. Circle with dot, observation made just after taking food; square with dot, smoking; * work done eight minutes after drinking fifteen cubic centimeters of whiskey." — DONALDSON, from LOMBARD.

undergoes rhythmic variations in the course of each twenty-four hours. Hence, at certain times of the day both nervous and muscular energy are naturally at their maximum. Those who wish to obtain the cream of brain energy for certain productions will do well to profit by this fact in actual life. The foregoing chart shows the fluctuations in voluntary muscular energy for each of the twenty-four hours.

It must be remembered that this chart is also in a measure indicative of the energy in the cells of the motor brain tract at different times of the day. When one lifts a weight, he starts by innervating the motor cells which flex the muscles concerned in the work. If the energy in these cells was below the average, the muscular response would also be below the average.

The truth that certain times of the day find the brain in a more energetic condition is often made evident in practical life. A professor gave the same extempore lecture on two different days; the first time at 11 A.M. He then showed easy mastery of his subject, and he held the attention of his audience easily from first to last. The second time he began speaking at 4 P.M., and he never once seemed to be master of the subject, although he was evidently labouring very hard to be impressive. Many of the audience were yawning and shifting their positions. In commenting afterward on his feelings that afternoon, he said that he had never experienced a sense of greater effort, that instead of the ideas flowing from him easily and naturally as on the morning of the previous lecture, he had to take a cudgel and drive them all out of the cave in which they seemed to be endeavouring to conceal themselves. Nevertheless, a part of the yawning of the audience was to be explained in terms of their own wearied condition. At 4 P.M. the nervous and muscular energy is at the lowest point reached during the day, hence the audience were in as poor a state to be energetic listeners as he to speak. Bicyclers making a tour have often declared that at 11 A.M. they would be riding swiftly with little effort, about 3 P.M. they would begin to feel much fatigued, while at 6 or 7 P.M. their strength would often seem to return like a tidal wave. We might say that, barring individual peculiarities, the chart given above represents in a rough way the energy for attention in cerebral cells. The strange fact that this is as great between 10 and 11 P.M. as at any time during the day, agrees well with the testimony of many authors. The writer is sure that he can think more quickly and easily at 10 P.M. than at 8 P.M., yet he prefers from 10 to 11 A.M. to any other hour. While we are not justified in asserting that the energy in sensory brain tracts follows the same curve as that for motor reactions, there is probably a close connection between the two.

Those who believe in long hours for school or mental work ought to remember this statement from Ribot: "Fatigue in every shape is fatal to memory. The impressions received under such conditions are not fixed, and the reproduction of them is very laborious and often impossible. Now fatigue is regarded as a state wherein, owing to the over-activity of an organ, the nutrition suffers and halts. When the normal conditions are restored, memory comes back again."[1]

A study of the physical aspects of attention is necessary in order that we may do the most effective mental work. If we notice ourselves carefully, we can often detect a distinct physical strain in attention. If we innervate our ears to catch the first sound of a coming footstep; if we continuously follow the flight of a bird across the heavens; if we pass our fingers over various fabrics to detect a difference, — we are conscious of a physical tension, which, if unintermitted, produces fatigue. The highest medical authorities agree that attention strongly directed to any part of the body will produce a physical change. If the attention is centred on the stomach, the digestion will suffer; if on the liver, that will become deranged. The vascu-

[1] Ribot's *Diseases of Memory*, Chap. V.

larity of bodily organs and calibre of the blood vessels can thus be made to undergo a change. In short, the physical aspects of attention are strongly marked.

It follows as a corollary from the physical basis of attention that it cannot be held at the same intensity for a long period. There are also two classes of objects to which the strongest will cannot long chain the attention. The first is an object which does not awaken interest, either directly or indirectly. Many persons have never learned that no amount of compulsion can rivet the attention to such an object.

The second class of objects which can claim but short-lived attention are those which present one unchanging aspect. It is by no means always necessary that there should be a new object to secure the attention again. A new phase of an old object is equally efficacious. Any one who can show an old thing in a new light, is always sure of a willing audience. Stone coal received little attention from men before they learned that it would burn. Then attention was at once directed toward it. So we become interested in the most common insects, flowers, and birds, as soon as a new attribute is discovered. The genius is he who shows us something new in an old thing, so that our attention is again turned toward it.

So far as we know, all energy, whether mental or physical, travels in waves. Attention rises and falls like the waves of the sea, and cannot remain long at the same level. If one will take a watch and remove it to such a distance that the ticking is barely heard, he will notice that periods when he can hear the sound alternate with those when he can not. These periods exhibit wave-like characteristics. If a water faucet at a little distance is turned, the same will prove true. The rise and fall of attention do not correspond to the periods of the sound waves. We may suppose that cellular vibrations, or some kind of molecular brain tension, determine this characteristic of attention, although we have no instruments sufficiently fine to enable us to demonstrate this.

The inertia inherent in all nerve cells must be overcome before they can act so as to rouse even reflex attention. We are thus protected against being overwhelmed by the myriad stimuli of slight intensity. Were the case otherwise, every variation in the density, temperature, saturation, and movement in the atmosphere would be the object of attention; so would the slight rustling of the leaves, the hum of insects. Bewilderment and speedy exhaustion would be the result of attention thus developed. The very stones, large and small, that lie on the surface of the earth, would be rolling around and perhaps crushing our feet, were it not for inertia, for the wind would blow them here and there. This dead and often despised quality of matter also fortunately makes itself felt in the region of mind, otherwise no one could think deeply on any problem for sixty consecutive seconds.

Our knowledge of the physiology of the brain does not enable us to explain the undoubted fact that the use of one part of the brain tends to increase the inertia of other parts. If our occipital lobes are tense with the exertion of seeing and distinguishing the different parts of an objeet, there will be less energy in the temporal lobes for hearing, and a greater auditory stimulus will be necessary to rouse their increased inertia. This fact accords with our muscular experiences. The use of some muscles drains energy away from others. If we are walking, we cannot lift as great a weight as when we are standing still.

What is termed the summation of stimuli is often necessary to secure effective attention. Brain cells which have had sufficient tension developed in them to take them half-way on the road to rousing attention often sink back into quiescence if the stimulus is not sufficiently intense, continuous, or added to by other stimuli. The writer, who extremely dislikes the flakes of lamp-black, as well as the odour caused by a lamp turned too high, was busy one evening while a cloud of the sooty smoke was pouring out of the chimney. He was for some time unaware of the fact. There was first a slight noise due to the intensely heated current of air. This stimulus did not attract attention. Next, there was a slight flickering which he failed to heed. There was added to this a strong odour, and still the sum was not sufficient. Finally, when the flakes of soot began to fall thickly on his paper and hand, he noticed the condition of the lamp. The sum of all these stimuli was necessary to attract his attention. There is an analogy between this and lifting a stone which requires four men to raise. One man may tug away without lifting it, so may three, but when the fourth man adds his strength, the stone is raised.

Men who engage in any kind of business are often called upon to apply the principle of the summation of stimuli. A striking show-window, displaying a variety of wares, will often attract one's attention so strongly that he will enter, although an adjacent store which makes less display really has a better stock. We frequently do not buy from the first, second, or third fruit vender that we pass. Attention is meanwhile developing, and we purchase inferior fruit at a higher price from a man farther on. Commercial travellers say that it is often an advantage to have a man with the same line of stock canvass a town just before they come. He overcomes the inertia of attention, and thoughts arise of the profit from handling that line, coupled with fears that another travelling man may not soon put in an appearance. When a second man does come, the tradesman is frequently ready to buy. A commercial traveller recently said that he sold the same line of goods to a dealer in hats at an average of a twenty per cent higher price than another agent had offered them a few days before. The brain is to a certain extent like a soil in which things must germinate and ripen before they can produce results.

There is an important deduction concerning sleep to be drawn from the study of the summation of stimuli. It by no means follows because three men could not lift a certain stone, that they were not at work trying to raise it. When stimuli pour into the sensory brain tracts of a sleeper, it must not be inferred that the cells are not thereby thrown into activity because consciousness is not affected. The majority of brain work is done *below* the threshold of consciousness, but it is nevertheless *work*, and all work involves wear and tear. In many of our large cities, the sensory brain tracts never have complete rest at any time during the twenty-four hours. The rumble of traffic on the paved streets assails the auditory tract of the sleeper all night long. The excitement spreads from these cells and radiates out along the nerve fibres, causing dreams. The sleeper awakes in the morning with a tired, jaded feeling, and is consequently unable to do the best work of which he might have been capable. The effect of light can be distinctly felt through the eyelids of a sleeper, and the occipital lobes are thereby set in action. The brilliant electric lights with which the streets of a city are illumined, are responsible for much brain action of this kind. Either the room must be so closed as almost to exclude air, or the stimulus from light must be felt during all the sleeping hours. One of the many reasons why the country is so healthy is because of the comparative absence of stimuli during the night. The brain is not goaded into action during sleep. Those are to be envied whose suburban homes allow them the quiet of the country at night and the benefits of the city by day. If we are compelled to pass our lives in the city, we should be careful to have our sleeping rooms where as few stimuli as possible may register themselves on our brains. If we do not, our central nervous systems will never be in a condition to do their best.

The question has been often asked, To how many things can we attend at one time? The physicist puts the query in this way: How many different points in the brain can affect consciousness at the same time? Until quite recently, attempts were made to settle the first question by an appeal to metaphysical theories. The soul was a simple indivisible unit, it was said, and as such it was impossible for it to contemplate more than one thing at a time. Then a psychologist suggested that such a theory would exclude the possibility of comparison, which necessitates attending to at least two objects at the same time. Finally a physiological psychologist determined to see if actual experiments would not be of value, as in the science of physics. A narrow blackboard was devised, down which a screen would slide, disclosing, as it dropped, a space about six inches square, on which different letters were marked. This space was left unclosed for about eight one-hundredths of a second, which is too short a time for the attention to wander consecutively from point to point.

From four to five disconnected letters or numerals are thus immediately perceived. The question is thus settled that it is possible for us to attend to five simple disconnected things at the same time. These do not represent the sum total of objects in consciousness, but only those in the focus or point of most distinct consciousness. Just as we call that part of the retina most sensitive to light the yellow spot, so we might metaphorically term attention the yellow spot of consciousness.

At a slight distance from the centre of vision, there are objects which we see with less distinctness. These decrease in clearness as we go farther from the centre. Beyond the circumference of vision they are not seen at all. The same is true of consciousness. Objects vary in distinctness by a regular gradation, until we pass beyond the twilight fringe to the regions of complete darkness.

It is probable that strong attention and tense activity in brain cells are correlated. Some persons with poor circulation and insufficiently nourished brains never know what really distinct attention is. The consciousness of such people is hazy, indistinct, like objects seen in a fog. It is probable that if the consciousness of different people could be laid side by side for comparison, we should see many gradations of distinctness, from noonday brightness to the glimmering twilight of almost habitual absent-mindedness. Many persons must be asked a question twice before their dull, poorly nourished brains are sufficiently roused to respond.

Numerous facts impress on us the truth that the nourishment of the central nervous system is an especially important preliminary requisite to its training. After the nutrition of the body has suffered through a fever or indigestion, the memory is always impaired. The nerve cells are nourished only by the circulating blood, hence anything that affects the activity of the heart or the quality of the blood also affects the energy with which the brain and the spinal cord can do their work. Persons who have cold feet, due to sluggish circulation, almost always complain of poor memories. We have seen that fatigue (p. 63) sometimes shrinks the nucleus of a cell fifty per cent. Nutrition of the very best kind is necessary to enable those cells repeatedly to regain their former volume. Their very integrity must suffer if such nutriment is not forthcoming.

Those who labour much with their brains need a more generous diet than any other class of people. Meat and fruits, combined with the proper exercise, should be eaten in abundance. The majority of brain-workers either undereat or do not eat the right kind of food.

Ribot thus emphasizes the importance of nutrition for the central nervous system :

"All forms of memory, from the highest to the lowest, have for their groundwork dynamic associations between the nerve elements and special modifications of these elements, at least of the cells. These modifications, resulting from a first impression, are retained by no inert matter — they do not resemble the impress of a seal on wax. They are impressed upon living matter. Now all living tissues are ever in process of molecular renewal, nerve tissue more than any other, and in nerve tissue the gray substance more than the white, as is proved by the extraordinary abundance of blood vessels pervading it. Now, since the modifications persist, it follows that the arrangement of the molecules of new-formed tissue must exactly reproduce the type of the effete molecules to which they succeed. Memory is directly dependent on *nutrition.*

"But not only have these cells the property of self-nutrition : they also possess, at least during a portion of their life, the power of reproduction. . . . All physiologists hold this reproduction to be simply a form of nutrition ; therefore the basis of memory is nutrition — the vital process *par excellence.* . . .

"This normal condition of the brain being granted, it is not enough that impressions be received ; they must be fixed, organically registered, incrusted, so to speak ; they must become a permanent modification of the brain ; the modifications impressed upon the nerve cells and nerve filaments, and the dynamic associations between these elements must be made stable. This result can be produced only by nutrition. The brain, and particularly the gray matter, receives an enormous volume of blood. In no other part of the body is the nutritive function so active or so rapid. We know not the inner mechanism of this function. The minutest histological research is unable to trace the arrangements and rearrangements of the molecules. We know only the effects — all beside is but induction. But all sorts of facts go to show the close connection between nutrition and memory.

"It is matter of every-day observation that children learn with wonderful facility, and that anything, as languages, which calls only for memory, is readily learned by them. We know, furthermore, that habits — that is to say, one form of memory — are far more easily formed in childhood, in youth, than in maturity. At that period of life, so great is the activity of the nutritive process that new connections are rapidly formed. In the aged, on the contrary, a rapid effacement of new impressions coincides with a considerable decline of this activity.

"These physiological and psychological facts all show that there exists between nutrition and retention the relation of cause and effect. There is exact coincidence between their periods of rise and fall. Variations short or long in the one are repeated in the other. If the one be active, or moderate, or languishing, so is the other. Hence the retention of recollections must not be regarded metaphysically, and as a 'state of the soul' subsisting no one knows where, but as an acquired state of the cerebral organ implying the possibility of states of consciousness whenever the conditions of consciousness are present."[1]

The writer has said elsewhere: "If a person lives on a skimmed-milk diet, he will think skimmed-milk thoughts.

[1] Ribot's *Diseases of Memory*, Chaps. I. and V.

That nation proverbially known as 'beef-eaters' has furnished the world the greatest literature of all time."[1]

In concluding this chapter, the apparently paradoxical statement should be emphasized that nutrition of the best kind depends on a state of antecedent fatigue. When nerve cells have been exercised, but not overfatigued, they are then in the very best condition for receiving fresh nutriment. We sometimes see persons, who seldom stir out of the house, pick things over at the table without eating scarcely anything, and we tell them that if they would exercise, they would have an appetite and grow stronger. Analogous advice should be given in the case of the nervous system. Nerve cells should be exercised to the point of reasonable fatigue, so as to be put in the proper condition for being made stronger by the nutriment which they will then be in a condition to assimilate.

[1] Halleck's *Psychology and Psychic Culture*, p. 53.

CHAPTER V

Environment and Training

Environment is a factor of special importance in the training of the central nervous system. Some persons have made the strange assertion that the individual would develop, as far as his potential capacities would allow him, no matter what his environment. They say that a child who has the potential capacity for speaking correctly, will use good English, although his environment would not allow him to hear a dozen grammatical sentences until he is fifteen; that a person would perform as much in the course of his life, no matter whether he lived in the tropics or in the temperate zone; that an orange tree will produce as much fruit in Labrador as in Cuba.

The number of those making such assertions is fortunately growing fewer. The history of every clime refutes them. Even schoolboys notice that the world's great authors and inventors are from a temperate climate, and that the vegetation of the frigid zone is stunted.

A simple experiment will enable us to determine the power of environment in the development of the same organism. If we take a tadpole, just beginning to shows signs of developing into a frog, and put him in a vessel of water which is kept in a dark room, at the end of thirty days we shall notice no perceptible advance toward froghood. If for one day we then admit light into his environment, there will be more advance than during the preceding thirty. If he is again kept away from light, his development will be retarded for an indefinite length of time. If he is finally put back in the sunlight, he will never make the frog which a more suitable early environment would have produced. It is plain that such a tadpole has something to develop, and it is further evident that those inherent capacities do not develop well unless the environment is suitable. The Mammoth Cave furnishes specimens of blind fish. They have rudimentary eyes, which have never developed in the absence of light.

We have already seen (p. 47) that human brains contain more or less undeveloped cells. It is impossible to see how these cells can fully develop, unless the environment affords the proper exercise. The auditory brain tract of a child may have wonderful potential capacities, but if there are no musical sounds in his environment, the tract will not fully develop. If we study the youth of great musicians, we shall find them living in a world of musical sound, in most cases, before the age of ten.

Beyond question, some kinds of environment afford more chances than others for the central nervous system to develop. While environment is in some respects relative to each individual, yet certain situations are in general better for the growing organism. A crowded tenement house is not a favourable place for the development of the nervous system of any child. Any youth is to be pitied who has never spent a part of his time in the country.

The city has many drawbacks for bringing up children. In the first place, it is cramped. Only those rooms into which the sunlight can pour, ought ever to be used for sitting or sleeping rooms. The sun, however, has small chance at the majority of city apartments. Space is also so precious that the most of the rooms are small. Some suggestive experiments have been made which emphasize the baneful effect of cramped quarters on growing animal life. A row of vessels, regularly increasing in size, has been set on the same shelf in a room. These have been filled with water, and a growing tadpole or a pond-snail placed in each vessel. Although all were treated alike, so far as the capacity of the vessel would allow, at the end of a certain period it was found that each tadpole or snail had developed proportionally to the size of the vessel; that is, the smallest tadpoles or snails were found in the smallest vessels; the next larger, in the next larger vessel. In connection with this, one can scarcely help thinking of the thousands of children whose playground is the little back-yard, frequently not so large as a good-sized room. It would be unfair to expect their development to be more than commensurate with their surroundings.

The country, especially in the summer time, appeals to all the senses more effectually than the city ever can. Everything, from the song of birds to the odour of flowers, is presented in its most appropriate natural setting. The wide expanse of field and wood allows full scope to motor activity. As we have seen, the motor brain tract is as important in a world of action as any other part of the nervous system.

It would be hard to state wherein the country in the summer time fails to afford the proper stimulus for developing the growing nervous system. Even an ordinary poultry yard may prove a developing factor in the environment of a boy who has been trained to habits of observation. The writer recently read a very interesting article illustrative of this very point. It is hard to see how better vacation material could have been furnished two boys for developing their senses and power of discrimination. The article says: "Living in Buffalo, the writer and a brother, who was an inseparable companion, boarded through the whole or a part of several seasons, sometimes six months together, on a farm in Orleans County. Our time was entirely our own, and, as we found little companionship among the busy country lads, many days might have hung heavily on our hands had we not been wholly content to spend the greater part of them among the chickens and the turkeys; only one season we added ducks. Our parents had taught us to love and observe nature, and we were well read for our years in natural history. What was of more importance, we had been led from early childhood to be exact and painstaking in all things. Our play with toys was tiresome to most boys by reason of its carefulness. Under such circumstances it will not, perhaps, be thought strange that either of us could tell every fowl, young or old, toward the end of each summer, by its name, and nearly all of them by their cackling. Usually, there were about one hundred on the premises. We not only knew their general appearance as we would familiar faces, but I think there is no doubt that a glimpse of even the half of any head in the barnyard would have been enough for instant recognition. We knew every hen's nest when the egg yield was two dozen a day, and my brother could promptly and with certainty sort out ten dozen eggs and tell which hen laid every one. When there were twenty half-grown cockerels on the farm, we could readily name any one which crowed out of sight."

The boys even studied motor inhibition in a rooster. When he started to crow, they threw food in front of him, but this was devoured by other fowls before he had finished crowing. The article continues: "His indignation was so amusing that we fell into the habit of teasing him in this way, until at last the old fellow began to practise choking down the rest of his crow when corn was thrown in front of him. Gradually he managed to stop more and more quickly, and in the end he would swallow his voice with a gulp, and snatch a bit of food as promptly as if he had not been crowing at all."

These boys also watched the initiation of motor action by the sense stimuli which kernels of corn furnished: "A half-brother of this rooster learned very quickly to crow for corn, once for every kernel. He used to stand before us and crow as regularly as clockwork, always stopping for his reward, and never expecting a second kernel until he had crowed again. When almost satisfied, he waited much longer between times, and at last walked contentedly away."

On another occasion, this same barn gave them a suggestion for practising their imaginations: "We dyed a speckled cock red with carpet-dye, glued a stiff, high comb of paper on his frost-amputated stump, and tied up his wattles under his throat. This overdid the business to such an extent that the other roosters fled from him in horror, as if he had been a hawk, and the Devonshire farmhand, looking at him in amazement, exclaimed 'Byes, what fresh bird have ye brought about here?'"[1]

This entire article, which is as interesting as a romance, illustrates the fine effects of a change of environment as a stimulus to training the senses. We find evidence in Milton's poetry that he was like these boys, affected by his environment in the country. The denizens of the barnyard also impressed him.

> "While the cock with lively din,
> Scatters the rear of darkness thin,
> And to the stack or the barn door,
> Stoutly struts his dames before."

[1] Karr's "Mental Traits in the Poultry Yard," *Popular Science Monthly*, September, 1888.

It is pleasant to think that Shakspere also found such sensory training in his environment. In his greatest play he says:

> "I have heard,
> The cock, that is the trumpet to the morn,
> Doth with his lofty and shrill-sounding throat
> Awake the god of day."

In order that the fullest development of any human being may result, there must be an occasional change in the environment. Darwin recognized the benefits of judicious change in the case of both animal and plant life. He says: "Small farmers who hold but little land are convinced that their cattle derive great benefit from a change of pasture. In the case of plants, the evidence is strong that a great advantage is derived from exchanging seeds, tubers, bulbs, and cuttings from one soil or place to another as different as possible. . . .

"As plants after once germinating are fixed to the same spot, it might have been anticipated that they would show the good effects of a change more plainly than do animals which continually wander about; and this apparently is the case. Life depending on, or consisting in, an incessant play of the most complex forces, it would appear that their action is in some way stimulated by slight changes in the circumstances to which each organism is exposed. All forces throughout nature, as Mr. Herbert Spencer remarks, tend towards an equilibrium, and for the life of each organism it is necessary that this tendency should be checked."[1]

A change in environment is necessary for the development of the human nervous system because of this very tendency toward equilibrium, of which Spencer speaks. This is the

[1] Darwin's *The Variation of Animals and Plants under Domestication*, Vol. II., pp. 127, 130.

tendency of the nervous system to adjust itself to repeated stimuli of the same kind, so that they produce less conscious effect. The countryman may become so used to the songs of the birds and the sight of the flowers that his ear and eye cause only semi-conscious response. We all remember how the first leaves of spring delight us. We look at them again and again and feel intense pleasure, but our eyes rest half-unconsciously on the magnificent foliage of a June forest. The countryman will notice far more of the sights of the city than its regular inhabitants, but when citizens go into the country, their central nervous systems are at first keenly responsive to its varied stimuli. It is a matter of common remark that persons from a distance must come to point out to us the wonders under our very feet. If we intend to describe a foreign country, we should begin as soon as we see it, and before our nervous systems are dulled by repetition and begin to respond with decreasing consciousness.

A change in human environment is as important as a change of place. We may for some time go along in our old ruts, making little advance, when association with a person from a distance may suddenly call into action all our latent powers. The writer knows a middle-aged man who would have been famous as a writer, instead of living unknown in a country village, had he felt the proper human stimulus and attrition. He has often said that if Macaulay had known no more stimulating environment, the wonderful *Essays* would never have been written. A man of genius will change, to a certain extent, all who come in contact with him; if of sufficient genius, he may almost usher in an Elizabethan Age. He gives no new potential capacities, but he develops latent ones. This is the reason why one teacher may get so much, and another so little, from the same class.

Sir Francis Galton appreciated the power in human environment when he said: "Those sudden eras of great intellectual progress cannot be due to any alteration in the natural faculties of the race, because there has not been time for that, but to their being directed in productive channels. Most of the leisure of the men of every nation is spent in rounds of reiterated actions; if it could be spent in continuous advance along new lines of research among unexplored regions, vast progress would be sure to be made. It has been the privilege of this generation to have had fresh fields of research pointed out to them by Darwin, and to have undergone a new intellectual birth under the inspiration of his fertile genius!" [1]

No environment can be satisfactory which allows mere sensory development and does not demand sufficient motor responses; or, in other words, sufficient action to keep one from deteriorating. Sir William Grove saw this truth strikingly exemplified in the case of animals. Speaking of the environment of the rabbit, he says: "If it gets a luxuriant pasture, it dies of repletion. If it gets too little, it dies of inanition. To keep itself healthy, it must exert itself for its food; this, and perhaps the avoiding its enemies, gives it exercise and care, brings all its organs into use, and thus it acquires its most perfect form of life. I have witnessed this effect myself, and that is the reason why I choose the rabbit as an example. An estate in Somersetshire, which I once took temporarily, was on the slope of the Mendip Hills. The rabbits on one part of it, viz. that on the hillside, were in perfect condition, not too fat nor too thin, sleek, active, and vigorous, and yielding to their antagonists, myself and family, excellent food. Those in the valley, where the pasturage was rich and luxuriant, were all diseased, most of them unfit for human food, and many lying dead on

[1] Galton's *Inquiries into Human Faculty and its Development*, p. 179.

the fields. They had not to struggle for life, their short life was miserable, and their death early; they wanted the sweet uses of adversity—that is, of antagonism. The same story may be told of other animals."[1]

Environment must, therefore, afford sufficient stimuli to develop the senses and to give room for sufficient motor action in the growing nervous system. Further, the environment must be sufficiently exacting to compel the proper amount of action. For a growing nervous organism, the country would, in consequence of these conclusions, seem the better.

Let us examine some noted authors to see if they uphold these theories. A great author must possess well-trained senses as well as be a man of action. Let those who think writing does not require energetic action, actually write a book. The majority of such will probably clamour for something easier before they have finished. A great poet must be something more than a dreamer: he must be a man of energetic action. We may therefore contend that great writers are a fair body of men to examine, for both their sensory and motor brain tracts must be well developed. Before Shakspere could write:

> ". . . daffodils
> That come before the swallow dares, and take
> The winds of March with beauty . . ."

the daffodils and the swallows must have been impressed upon his senses in that incomparable scenery of Warwickshire. Before these materials found themselves in a finished drama, there must have been severe action on the part of the writer to select, condense, arrange, and create from faint suggestions. If any one thinks the opposite, let him prove it by his own productions. When we examine the lives of noted men, we

[1] *Antagonism:* a Lecture before the Royal Institution of Great Britain April 20, 1888.

shall learn what kind of environment has been a factor in developing them. If we find any factor common, to a great extent, we have made a discovery of practical worth for developing a human being.

Amid the obscurity in which Chaucer's early life is wrapped, some things are clear. We know that although he was born in London, he spent a part of his youth in the country. He was page to a princess, who spent a portion of each year at her country seat at Hatfield in Yorkshire. Apprenticeship as a page demanded great activity. The country so impressed his youthful sensory brain tracts, that the man was able to picture some of its aspects with wonderful vividness. What he saw is to-day affecting us, from the daisy to the sweet showers of April falling on a world awaking to new and happy life. Chaucer was also considerable of a traveller, visiting France when he was about twenty, and Italy when he was a little over thirty. We notice, then, that he had in his youth both city and country life, and that his environment changed before his nervous system became dulled and unresponsive to any one kind.

Shakspere's case is so important that it demands special investigation in another chapter. We may say here that his youth was passed amid the finest rural scenery in England, and that his young manhood found him in active London.

John Milton was born in London, but he was fortunate enough to have five years of pure country environment at the time he was entering on full manhood. One of his biographers says: "The country retirement in which the elder Milton had fixed himself was the little village of Horton, situated in that southernmost angle of the county of Buckingham which insinuates itself between Berks and Middlesex. . . . There was no lack of water and wood, meadow and pasture, closes and open fields, with the regal towers of Windsor, 'bosom'd high in tufted trees,' to crown the landscape." Of the poems written there, the same writer says: "All rural sights and sounds and smells are here blended in that ineffable combination which once or twice, perhaps, in our lives has saluted our young senses before their perceptions were blunted by alcohol, by lust or ambition, or diluted by the social distractions of great cities."[1]

As we ask whether this environment was favourable to activity, we learn that during those five years in the country he produced *L'Allegro*, *Il Penseroso*, *Comus*, and *Lycidas*. Some critics think *Comus* the finest of Milton's productions. Almost all unite in calling *Lycidas* the high-water mark of lyrical poetry. Milton then left Horton and travelled on the Continent. Returning, he became one of the most active statesmen during the period of the Commonwealth. At the age of forty-three he was totally blind. It was well that his environment had already given him sufficient material for the *Paradise Lost*.

John Locke, the philosopher, was born in a small village in the north of Somersetshire. A biographer says: "Locke, then, may be regarded as having been fortunate in early surroundings. Born in one of the more charming of the rural districts of England, not far, however, from a city which was then one of the most important centres of commerce and politics, . . . there seems to have been nothing in his early life to retard or mar the development of his genius."[2]

John Bunyan was born in the hamlet of Elstow, a mile and a quarter from the town of Bedford. Environment did all in its power to make him the author of *The Pilgrim's Progress*. He was born of very sensible parents, who did their part well. Bedford had been the scene of an incident which must have

[1] Pattison's *Life of Milton*, Chap. II. [2] Minto's *Life of Locke*, Chap. I.

deeply impressed Bunyan's boyhood, and made him feel the power of conscience. Froude, commenting on the traditions of Bedfordshire, says of this special event: "One of them, which had deeply impressed the imagination of the Midland counties, was the story of 'Old Tod.' This man came one day into court in the Summer Assizes at Bedford . . . to demand justice upon himself as a felon. No one had accused him, but God's judgment was not to be escaped, and he was forced to accuse himself. 'My lord,' said Old Tod to the judge, 'I have been a thief from my childhood. I have been a thief ever since. There has not been a robbery committed these many years, within so many miles of this town, but I have been privy to it.' The judge, after a conference, agreed to indict him of certain felonies which he had acknowledged. He pleaded guilty, implicating his wife along with him, and they were both hanged." [1]

The allegorical warfare of life was more deeply impressed upon Bunyan by the Civil War, in which he was an actual soldier. The Restoration saw the officers come, tear him guiltless away from his little blind daughter, and shut him up in squalid Bedford jail for twelve years. As in the case of Milton, environment had already given Bunyan sufficient material, which confinement in that gloomy jail enabled him to transmute into *The Pilgrim's Progress*.

Passing over Dryden, Addison, and Fielding, who were born in the country; Swift and Pope, who spent much of their time in the country; Defoe, who had all kinds of environment in his extensive travels; Dr. Johnson, who was born in a small town, — we come to authors nearer our time.

Sir Walter Scott was born in Edinburgh, but spent a part of his boyhood on a farm at Sandyknowe, which was situated

[1] Froude's *Life of Bunyan*, Chap. I.

amid a romantic scenery. Speaking of this time of his life, Scott says: "My health was by this time a good deal confirmed by the country air, and the influence of that imperceptible and unfatiguing exercise to which the good sense of my grandfather had subjected me; for when the day was fine I was usually carried out and laid down beside an old shepherd, among the crags or rocks round which he fed his sheep. Here I delighted to roll about on the grass all day long in the midst of the flock, and the sort of fellowship I thus formed with the sheep and lambs impressed my mind with a degree of affectionate feeling towards them which lasted throughout life. . . . I, who in a city had probably been condemned to hopeless and helpless decrepitude, was now a healthy, high-spirited, and, my lameness apart, a sturdy child." At the age of fifteen Scott first saw the vale of Perth. He says of it: "Since that hour, the recollection of that inimitable landscape has possessed the strongest influence over my mind, and retained its place as a memorable thing." Readers of his poems and romances have reason to be thankful for his early environment.

William Wordsworth was born in a small town in Cumberland, and he passed the most of his boyhood as well as of his later life in the wonderful Lake District. A biographer says of him: "Born at Cockermouth, on the outskirts of the district, his mind was gradually led on to its beauty; and his first recollections were of Derwent's grassy holms and rocky falls, with Skiddaw, 'bronzed with deepest radiance,' towering in the eastern sky. Sent to school at Hawkshead at eight years old, Wordsworth's scene was transferred to the other extremity of the Lake District. It was in this quaint old town on the banks of Esthwaite Water, that the 'fair seed-time of his soul' was passed."[1] It should be noted that he travelled on the Conti-

[1] Myers' *Life of Wordsworth*, Chap. IV.

nent as well as over England, and hence felt the beneficial effects of change.

Coleridge was born in the small town of Ottery St. Mary in Devonshire. He has told us that "so deeply impressed upon his mind are the scenes of his childhood that he can never close his eyes in the sun without seeing afresh the waters of the Otter, its willowy banks, the plank that crossed it, and the sand of varied tints that lay in its bed." In his early manhood, he and Wordsworth lived for a while only a short distance apart near the Quantock Hills in Somersetshire. While roaming over those hills in company with Wordsworth and stimulated both by him and by the sight of the sea, Coleridge thought out the poem of *The Ancient Mariner*. The environment, both natural and human, reacted on Wordsworth, and he did excellent work. Afterward we find both these poets living near together in the Lake District. Coleridge also travelled abroad and changed his environment frequently.

Byron was born in London, but was soon after taken to Aberdeen. At the age of eleven he went to live for a while at the romantic Newstead Abbey in Nottingham. He also travelled widely over the Continent.

Shelley was born in a country home in Sussex. Later in life he used to amuse himself by drawing the fir-trees and cedars which grew around his birthplace. He went to school at various places. For a while after his marriage he lived in the Lake District and in other picturesque places before going abroad.

Macaulay was born in a Leicestershire country home. His travels in India enabled him to write two of his finest essays, — on Warren Hastings and Clive. Carlyle was born in a little country town in Scotland. De Quincey first saw the light in a fine home in the suburbs of Manchester, and he lived for some time in the Lake District. Ruskin was born in London, but he says: "The first thing which I remember as an event in life, was being taken by my nurse to the brow of Friar's Crag on Derwentwater." Tennyson was born in Lincolnshire in the parish of Somersby, containing about fifty inhabitants.

Nathaniel Hawthorne was born in Salem. On one side of the town lay the open country; on the other, the sea. To the west of his home was Gallows Hill, associated with the most weird stories and terrible persecutions in America. At the age of fourteen he was taken to a forest home in Maine, where he says that he lived like a bird of the air. The environment of his native land was supplemented by extensive travel abroad.

A Scottish critic says that no one has taught more people to love poetry than Longfellow. The environment of a man who has brought an added pleasure into the life of so many, is worthy of notice. Longfellow was born in Portland, Maine. Of his birthplace, a biographer says: "Portland, the 'Forest City,' is beautiful in these days of ours, and will always be beautiful, with its great gulf of rolling blue, Cape Elizabeth at one horn, and at the other the miniature archipelago called Casco Bay, — the low hills of Munjoy and Bramhall piled up behind the houses, backed again by stretches of the noblest woodland. Every street has its trees."[1] These scenes reappear in the poetry of the mature man:

"Often I think of the beautiful town
That is seated by the sea;
Often in thought go up and down
The pleasant streets of that dear old town,
And my youth comes back to me.

* * * * *

"I can see the shadowy lines of its trees,
And catch, in sudden gleams,

[1] Robertson's *Life of Longfellow*, p. 14.

The sheen of the far surrounding seas,
And islands that were the Hesperides
Of all my boyish dreams.

* * * * *

"I remember the black wharves and the slips,
And the sea-tides tossing free;
And Spanish sailors with bearded lips,
And the beauty and mystery of the ships,
And the magic of the sea.
And the voice of that wayward song
Is singing and saying still:
'A boy's will is the wind's will,
And the thoughts of youth are long, long thoughts.'"

Longfellow travelled abroad and felt the stimulus of a new environment.

England's greatest soldier-statesman, Oliver Cromwell, was born in the little town of Huntingdon, surrounded on all sides by the green fields. At the age of seventeen he went to Cambridge University. In temperament, he might have been called a "motor"; that is, one in whom a slight sensory or ideational stimulus produced more than the customary motor reaction. Fortunately, Cambridge furnished plenty of active games for a type of this sort. We find some early biographers complaining that he paid more attention to football, cudgels, and other boisterous games than to his studies. Others also had good reason to regret this early motor training, especially Charles I., the Irish, and the Scotch.

John Churchill, Duke of Marlborough, was born in the country parish of Musbury in Devonshire. At the age of seventeen he was an ensign in the foot guards. Not long after, he saw service in Tangier, and was fighting in Flanders. He was of the "motor" temperament, like Cromwell, and early environment was favourable for developing this.

A study of the early history of these eminent men has shown that the majority of them had their sensory brain tracts developed to a considerable degree by the incomparable stimuli of the country. Since there is more room for exercise in the country, more green fields in which to romp and play, more groves and forests in which to wander, the motor brain tracts are likely to receive better training in such tempting environment. Again, we notice that nearly all these men travelled either in their own land or abroad. This is what we might have expected, since a study of the nervous system, and especially of the laws of attention, has shown us that unvarying stimuli gradually elicit less and less attention, although they may be of the very finest sort. A change in this environment is occasionally necessary to awaken us thoroughly and to make us men of action. But we must beware of thinking that change in environment means change of place. In an old place, we may fall under the influence of a new stimulus. A new acquaintance or the works of a writer may inspire us to do things which we should never otherwise have attempted. A stagnant neighbourhood has been the graveyard of many a potential tendency toward human action of high merit.

Before the central nervous system can be properly trained, the power of environment must receive more recognition. Potential capacities will not become actualities unless the environment affords the proper stimuli to develop those germinal powers.

How, then, can the nerve cells of poor children in the city be trained? It is needless to deny that absolute poverty is a drag, that few of the millions of the poor ever receive sufficient stimulus to incite them to change their condition and to rise in the world. If, however, a little taste of better things can be given, the thirst for more may become insatiable. There are few cities so large that the children cannot be taken on a Saturday afternoon, or on a Sunday, if no other time is possible, to the country, where the song of the bird, the perfume of the flower, the velvety touch of the grass, the sight of the leaves and the animals, and the motor responses thereto, will leave their lasting imprint upon the impressible nerve cells of the child.

CHAPTER VI

Age and Training

In education, the world has not yet practically realized the very important truth that youthful nerve cells alone are easily modified by training. The old theory that education consists solely in modifications in an immaterial entity has worked untold damage. It was argued that the immaterial never grew old, and that it could be trained as well at one time as at another. From this mistaken notion arose such adages as: "It is never too late to be what you might have been." It would be nearer the truth to say: "It is always too late to be what you might have been." With each advancing year, this becomes an absolute truth in the case of the vast majority who have reached the age of twenty.

It may be true, as we believe it to be, that education consists in developing a mind as well as mere brain cells; but the mind, for its materials, is completely at the mercy of the nervous system. A well-trained nervous system is the greatest friend that the mind can have. An ill-trained nervous system is a relentless enemy to the higher mental powers. It follows its victims and thwarts their aims until the pitying grave stops it. The writer can never forget the despair of a man who had become wealthy, and who wished to go into educated society. Early associations had trained his motor mechanism of speech to say: "He done wrong. I laid down. They set down and rested. I could have went." He procured teachers to instruct him in the right forms, and he finally learned them so that he could write them out correctly after a little study. But alas! he could not talk with his pen or with his fingers. The brain cells governing the vocal muscles worked automatically as they had been early habituated. This automatic working was followed, but not preceded, by consciousness. Not until after the words had escaped him, would he know that they were wrong. The brain cells in his third left frontal convolution, with the vocal habituation due to them, were an enemy watchful and relentless enough to keep him out of educated society.

Roughly speaking, the plasticity of nerve cells is inversely proportional to their age. A woodchopper may sharpen his axe as well the next week or the next year; a man owning mineral land may mine the coal now or wait twenty years, as he chooses, knowing that it will not deteriorate. But the nervous system can be effectively trained only in youth. An adult may be approximately defined as the sum of his youthful nerve reactions, which tend to perpetuate themselves.

Youthful nerve cells are like freshly mixed plaster of paris, and, like it, they soon lose their plasticity. Anything reasonable can be done with the youthful nervous system. If the training is deferred, it will soon be too late to accomplish much. Habits are early formed, and after they have once become fixed, they rule us with the grasp of a Titan. "Already at the age of twenty-five you see the professional mannerism settling down on the young commercial traveller, on the young doctor, on the young minister, on the young counsellor-at-law. You see the little lines of cleavage running through the character, the tricks of thought, the prejudices, — the ways of the 'shop,' in a word, — from which the man can by-and-by no more escape than his coat-sleeve can suddenly fall into a new set of folds. . . . Hardly ever is a language learned after twenty, spoken without a foreign accent; hardly ever can a youth transferred to the society of his betters unlearn the nasality and other vices of speech bred in him by the associations of his growing years."[1]

Investigations of the growth and increase in weight of the nervous system have served to emphasize the necessity for early training. Vierordt gives the average weight in grammes of the male brain at various ages as follows:

New-born child	381 grammes.
1 year	945 grammes.
5 years	1263 grammes.
10 years	1408 grammes.
15 years	1490 grammes.
20 years	1445 grammes.
25 years	1431 grammes.

These figures show that the male brain attains its maximum weight by the age of fifteen. The female brain reaches its maximum slightly earlier, between ten and fourteen.

It is, however, probable that in the most favoured classes in the community, and especially in the cases of those who keep the brain properly exercised, the brain weight may keep on increasing until the age of twenty, and possibly to a later period. Venn[2] measured the heads of Cambridge students at various times and found that the head increased in size during the entire course. This has not been shown to be true except in the cases of those who give their brains regular exercise in a judicious way. It is highly probable that such exercise tends to prolong the period of nerve plasticity. The brains furnishing the weights given above did not come from

[1] James' *Principles of Psychology*, Vol. I., p. 121. [2] *Nature*, 1890.

the most favoured classes, but they probably afford good average data.

The brain certainly begins to decrease in weight in the latter part of middle life and before old age can be fairly said to have begun. No definite time can be set for the beginning of this decrease; indeed, it probably begins at different times in different people. The brain weights of eminent men who died late in life, tend to show that in their case loss in weight was deferred to a late period. Their brains were probably at birth of a superior kind, but the right exercise, judiciously continued into old age, may have been a factor in postponing the decline. Examinations of the convolution immediately in front of the fissure of Rolando have shown that the fibres of association increase in number until about the age of thirty-three, when a decrease probably begins. Few, if any, tracts thus far examined indicate increase after thirty-three, although decrease does not begin in some convolutions until considerably later. As these fibres are required to explain the physical side of thinking, and the association and correlation of activity in various parts of the brain, we should naturally suppose that they would not begin to decrease in number until late in life. The fact that they do not increase after thirty-three agrees with the conclusions of those who believe that no one gets an absolutely new idea into his head after that time.

Youthful nerve cells possess a remarkable power of regeneration and recuperation. A young person recovers quickly from over-fatigue. The old frequently never completely recover from such fatigue, or if they recover at all, progress is very slow. Now, fatigue is a condition of advancement, for this comes as the result of work. The quicker the recuperation, the sooner can the work be again resumed. In this respect, especially, does youth have a vast advantage over age.

Darwin calls attention to the fact that the youthful cells of some of the lower order of animals can reproduce lost parts of the body. He says: "Spallanzini cut off the legs and tail of the same salamander six times successively, and Bonnet did so eight times; and on each occasion the limbs were reproduced on the exact line of amputation, with no part deficient or in excess. An allied animal, the axolotl, had a limb bitten off, which was reproduced in an abnormal condition, but when this was amputated, it was replaced by a perfect limb. The new limbs in these cases bud forth, and are developed in the same manner as during the regular development of a young animal. . . .

"The power of re-growth is generally much greater during the youth of an animal or during the earlier stages of its development than during maturity. The larvæ or tadpoles of the Batrachians are capable of reproducing lost members, but not so the adults. Mature insects have no power of re-growth, excepting in one order, whilst the larvæ of many kinds have this power." [1] While youthful human cells cannot reproduce an amputated leg, they do speedily repair many minor injuries from bruises, cuts, and burns. After a period of very fatiguing mental work, youthful brain cells will rise from a night's sound sleep with all the freshness of a spring morning, whereas an older person may complain of weariness all the next day or even longer. If we watch a wearied child, we may notice the precise physical expression of old age appear on his countenance. A night's sleep will make the little fellow young again. The difference between a young and an old nerve cell does not consist in the supposed fact that the one does not, while the

[1] Darwin's *The Variation of Animals and Plants under Domestication*, Vol. II., p. 357.

other does, become exhausted. Both become exhausted, but the young nerve cell speedily regains its lost strength, while the old does not. Again, judicious exercise may speedily enlarge the storage facilities of a young cell and make it stronger than before.

Early exercise of any kind seems to change the nerve matter in surprising ways, so that its entire subsequent reactions toward certain objects may be afterward changed. Darwin gives some striking instances of this: "An animal when once accustomed to an unnatural diet, which can generally be effected only during youth, dislikes its proper food, as Spallanzini found to be the case with a pigeon which had been long fed on meat. The caterpillars of the *Bombyx hesperus* feed in a state of nature on the leaves of the *Café diable*, but, after having been reared on the Ailanthus, they would not touch the *Café diable*, and actually died of hunger." [1] Human beings afford instances almost as striking as these. If a child is brought up on highly seasoned foods and artificial drinks, he can hardly endure a change later, although his former diet may be ruining his health.

The only reason why socialism does not become more rampant is because the poor are early habituated to their lot. A life of fashion, or any mode of living which made different demands on them, would be irksome. If they started to break loose in some unknown direction, they would either be at a loss to determine where to go, or if they reached some new situation, they would find themselves unsuited to it. Early training inexorably determines one's attitude toward the world, and even the comfort one takes in this or in that sphere. Sailors early accustomed to the cramped quarters, to the mo-

[1] Darwin's *The Variation of Animals and Plants under Domestication*, Vol. II., p. 294.

notony and the hard fare of the sea, have declined easier positions ashore and looked forward with pleasure to the day of sailing. Men sentenced to prison while young have begged to be readmitted after they have been released. They had grown accustomed to the prison routine, and they found no place into which they could fit in the outside world.

We ought not only to begin training the nervous system early, but this training should be of the right kind. Those persons who accustom their brains to respond only to *simple* sensori-motor reactions, will soon be left behind in the struggle for existence and displaced by others. By simple sensori-motor action we mean cases where a simple sensation is followed by an invariable motor reaction of the same kind. Instances of this are to be found in all highly specialized manual work of the routine kind, such as cutting out the heel of a shoe, making one special part of a watch, or of any other kind of machinery, rolling cigars, sawing out buttons, or even typewriting. The latter furnishes a good example of simple sensori-motor action, because the sight of the letter on the keyboard is to be followed by the invariable muscular action in striking it.

Sir Crichton Browne found that English weavers, button-makers, and potters, who for the most part employ simple sensori-motor action, arrive at their maximum proficiency at thirty years of age. Whenever they have a certain sensation from their work, whether of sight, sound, or touch, the motor reaction following this sensation is of the same kind. Because of this so-called expertness in one line, the workmen do, indeed, improve rapidly for a limited period. It is further true that the world demands this expertness and that life furnishes young people in sufficient quantity to take the place of the old, the moment they begin to show signs of a decline. If one can find a niche in life where he is not called on to respond to these over-specialized simple sensori-motor actions, he by all means should endeavour to occupy such a place of broader activity. Over-specialization in one direction must mean corresponding lack of exercise in another. This state of affairs cannot be healthful to the nervous system, for the unused parts must tend to atrophy, while those constantly exercised are liable to feel the bad effects of over-exertion. From this point of view, these figures given by Browne are worthy of remembrance. He found that a sawyer of vegetable ivory buttons could at the age of forty produce one hundred gross a day; at forty-five, eighty gross; at fifty-five, sixty gross; at sixty-five, forty gross.

Contrast with this the statements of Galton and Venn, which certainly tend to show that general exercise of the brain is a concomitant of prolonged growth: "Although it is pretty well ascertained that in the masses of the population the brain ceases to grow after the age of nineteen, or even earlier, it is by no means so with university students."[1] "Comparing the 'head volumes' of the students, two facts claim notice, viz., first, that the heads of the high-honour men are distinctively larger than those of the pass men; and, second, that the heads of all alike continue to grow for some years after the age of nineteen."[2] These statements were made after careful measurements of the heads of Cambridge students at various times during the undergraduate period. We have already seen that the brains of the less favoured population attain their maximum weight by the age of fifteen.

We must, however, beware against thinking that proper exercise can prolong brain growth indefinitely. It is well here to repeat our former statement that it is highly probable that

[1] Sir Francis Galton, *Nature*, Vol. 41, p. 454. [2] Venn, *Nature*, March, 1890.

one seldom gets an absolutely new idea into his head after he is thirty. After that period he may erect a wonderful structure of ideas upon foundations *already* laid, but that is all. If any subsequent structure is to be reared, an ample foundation to support it must be laid before that time. If these statements are true, they should be capable of verification from the lives of the world's great men. An examination of them will show the correctness or the falsity of this position. Such investigations are worthy our attention because the world is yet altogether too much of the opinion that there is time enough to *begin* to do a thing. The writer has heard many a person lament because the absolute necessity of early training and of an early start on the general lines of his life's work was not impressed on him. Many a person has drifted along, feeling that there would be time enough by-and-by. There is one motto which a study of the nervous system specially impresses on us: "By the streets of By-and-By, one arrives at the house of Never."

Alexander the Great had conquered Greece at twenty-one, Persia at twenty-five. He was dead at thirty-three. Sulla is on record as having detected the capacity of Julius Cæsar at the age of seventeen. When twenty-nine, Hannibal crossed the Alps with his victorious army, and two years later won the greatest victory of his life. The death of his father gave William the Conqueror the dukedom of Normandy at the age of ten. During his teens he fought and reduced to submission the rebellious Norman barons and made his power almost absolute, or he could never have stood on the victorious field of Hastings at the late age of forty-one and thereby changed the history of the world. Speaking of the latter part of his life, Freeman says: "Nearly the whole of William's few remaining years were spent in a struggle, which in earlier times he would surely have ended in a day." Before he was thirty, Oliver Cromwell was a member of the parliament which passed the famous Petition of Right. Environment gave him no chance to be a leader on the battlefield until he was in his forties, but he had already had experience in directing men. We have already seen that even in college he was noted for the motor development which indicated the man of action. Marlborough is often cited as a man who did not develop until late in life, but it is forgotten that at the age of seventeen he was an ensign in the foot guards, and that at thirty-two he had distinguished himself in the war in Flanders. Napoleon was master of Italy at twenty-five, the arbiter of Europe at thirty-five. When forty-six, his star sank behind the smoke of Waterloo. Military critics have said that the Napoleon of thirty-five could have won that battle easily. Wellington was an ensign at eighteen, a major at twenty-four, a distinguished colonel at twenty-five. Martin Luther when thirty-four protested against the sale of indulgences. Had he been older, he might have hesitated for fear of the consequences. Henry VIII. was in his thirties when he took a momentous step which changed the history of England.

Before Shakspere was thirty-five he had produced some of his immortal plays. He probably never wrote a line of a play after passing the fourth decade of his life. At fifty-two the master singer of all time was dead. Strange to say, Milton has been claimed as an exception to the rule of early development in the rôle of poet. The facts show exactly the opposite conclusion. When twenty-one he wrote the *Hymn on the Nativity*. Some eminent critics consider *Comus* the finest thing he ever did. He produced this when twenty-six. Almost all critics agree in calling *Lycidas* the high-water mark of English lyrical poetry, and this was written at twenty-nine.

It is true that he was nearly sixty when he finished the *Paradise Lost*, but we do not claim that a man cannot do anything great at that time, but simply that the necessary foundation for that greatness must have been laid by a proper youthful development of the central nervous system. Bunyan had begun the greatest allegory in the world in the early part of his thirties, but he had passed through the experience of the immortal Pilgrim some time before. Byron and Burns were dead at thirty-seven; Marlowe and Keats, before they were thirty; and Shelley, before he was thirty-one. Coleridge, in the opinion of many, wrote the finest thing he ever produced, *The Ancient Mariner*, at twenty-five. Before Scott was in his teens, he was training himself for his future work by seeing how well he could tell romances to the High School boys at Edinburgh. Berkeley had thought out his ideal philosophy at the age of eighteen, although his work, *The New Theory of Vision*, was not published until he was twenty-four. This has been called "the most epoch-making work in the history of psychology." Another famous philosophical work, which roused Kant from his dogmatic slumber, Hume's *Treatise of Human Nature*, was published when he was twenty-seven. At the age of twenty-five, Newton had outlined the most of his famous discoveries. Mrs. Harriet Beecher Stowe was in her thirties when she wrote *Uncle Tom's Cabin*.

Mozart, Beethoven, Mendelssohn, Schubert, Schumann, Auber, Weber, and Cherubini had produced original musical compositions before the age of thirteen. Professor Sully[1] has made a study of certain classes of eminent men with reference to their early development. He says: "What proportion of eminent musicians showed marked taste and ability as children? In order to answer this question I have gone through forty

[1] *Popular Science Monthly*, Vol. 29.

names. Of these I find that thirty-eight displayed a decided bent to the art before the age of twenty." When we realize that the auditory brain cells demanded early cultivation while still plastic, and that the motor connection between the cells preserving the modification caused by the sounds and the muscles employed in playing the notes, must have been developed early, the large percentage of early development among musicians need cause no surprise.

In the case of artists and sculptors, Sully says: "I have taken fifty-eight artists, consisting of painters, sculptors, and architects, of whose early years I have been able to obtain any information. Of these I find that forty-two — that is to say, about three out of every four — are credited with having shown a decided skill before the age of fifteen. . . . Michael Angelo produced great works by nineteen. Raphael painted fine pictures at twenty-one. Titian became a distinguished painter at about twenty. . . . Holbein is known to have painted good works at the age of fifteen, and at nineteen produced fine examples of finished portraits. Van Dyck, too, painted exquisite portraits at twenty-one. Rubens had made his mark by excellent work at twenty-three. Rembrandt was famous at twenty-four. . . . I cannot find an instance of artistic fame having been reached after the age of forty."

In the case of poets, Sully says: "Among German poets, Goethe, the greatest, is also the most precocious. He is said to have composed dialogues between six and eight. His first poems date from the sixteenth year, and by twenty-two he sounded in his *Götz von Berlichingen* the new national note in German drama. Among French poets, Alfred de Musset, who had excited the envy of his comrades at school by his quickness, composed poems at fourteen. Perhaps, however, the most valuable example among French poets is Victor

Hugo, who was called an 'enfant sublime,' began as a schoolboy to write poems, both translations and original compositions, by sixteen produced original works of lasting value, and by twenty-five was the acknowledged leader of the Romantic movement. . . .

"Poets rank high, too, in the matter of early production. After going through a series of sixty names, I find that thirty-eight, or very nearly two-thirds, wrote before twenty. Of the others, seventeen began to write before thirty. Thus only five, that is to say, one out of every twelve, took to poetic composition after thirty." Turning to writers of fiction, he says: "Taking twenty-eight novelists, I find that in twenty-one cases, that is, in three cases out of four — there is evidence of imaginative power showing itself before twenty."

In the case of men of science, early development is also marked. He says on this point: "I find after going through a list of thirty-six, that twenty-seven, or three-fourths, have given distinct evidence of a bent to science before twenty. . . . Out of a list of thirty-one, seven certainly wrote memoirs or other works under twenty; fifteen gave out their first known production between twenty and twenty-five; three began to write between twenty-five and thirty; leaving six who, so far as I can judge, entered on the productive stage after thirty.

"In science, as in the more serious department of letters, fame is sometimes reached suddenly by the production of a great work, the fruit of many years of study. Harvey's publication of his great discovery at the age of fifty is a case in point. It is to be remembered, however, that Harvey had expounded his theory in lectures some twelve years before this date. And the same kind of remark applies to Darwin and others who first gave to the world epoch-making truths at a somewhat advanced age; we commonly find that the actual discovery dates from a much earlier period, the promulgation of it being deferred till it was ready to be presented in a definite and verified form."

We can hear some objector saying, "These conclusions are drawn from an examination of geniuses only. Ninety-nine per cent of humanity develop later." If there were any consolation in such an argument as this, the most of us would gladly welcome it, but alas! there is less than none. We have already seen that it is altogether probable that the brains of geniuses, and of all who early strengthen their nerve cells by the proper exercise, remain plastic longer than the average. If there is any one who could afford to defer early training, it is a genius, since his period of plasticity is longer. The person of ordinary ability needs to begin earlier to train his nervous system, while the brief morning of plasticity lasts.

We may end the discussion of this very important subject with the following from Dr. Carpenter: "The modifiability which is characteristic of the nervous organism as a whole during its earliest stages, continues to show itself in each individual organ until its evolution is complete. Thus it is a matter of universal experience that every kind of training for special aptitudes is both far more effective, and leaves a far more permanent impress, when exerted on the *growing* organism, than when brought to bear on the adult. The effect of such training is shown in the tendency of the organ to 'grow to' the mode in which it is habitually exercised, as is evidenced by the increased size and power of particular sets of muscles, and the extraordinary flexibility of joints, which are acquired by such as have been early exercised in gymnastic performances. . . .

"On the other hand, from the time that the brain has attained its full maturity, the acquirement of new modes of action, and the discontinuance of those which have become habitual, are alike difficult. Both the intellectual and the moral character have become in great degree fixed; so that, although new impressions are being constantly received, they have much less power in directing the course of psychical action than they had at an earlier period, — that course being henceforth rather determined by the established uniformities, and by the volitional power of selective attention. The readiness with which new knowledge is now acquired, depends much more upon the degree with which it 'fits in' with previous habits of thought."[1]

[1] Carpenter's *Mental Physiology*, Chap. VIII.

CHAPTER VII

General Sensory Training, with an Examination of the Character of the Sensory Images employed by Shakspere and Milton.

The necessity is apparent for developing by the proper exercise the various muscles of the body. The muscles of the chest, back, loins, limbs, all need fitting exercise in youth. Many a child has not deepened a narrow chest because of the lack of the proper exercise during the growing time. In the same way many persons have become narrow brained; that is, they have failed to develop their potential brain capacities.

The case of Laura Bridgman shows that the cortex of the brain demands for its development proper sensory exercise. Because of her early blindness the visual centre in her occipital lobes never fully developed. The cortex was thin and the cells undeveloped. If the proper sensory stimulus does not flow into the brain at the fitting time, we can hardly escape concluding that the brain will never reach its full development and that the unfortunate possessor will be handicapped for life. If these undeveloped spots are allowed to pass the plastic stage, they will remain permanently in that condition.

All the higher structures of knowledge are built upon this sensory development. If the foundation is hazy and ill-defined, we must remember that the structure reared upon it can be no firmer than its support. All thought, all imagination, at the last analysis rest upon this sensory substrate.

In order that sensory brain tracts may be properly developed, there are two indispensable conditions, — the training must be early, and of the right kind. If young birds are brought up where they cannot hear the song of their own species, they will never at a later time be able to sing the pure song of their kind.

Modern man has in many cases so diminished his sensory training that he is only a pitiful fraction of a man. With many, the visual centre alone receives anything like adequate exercise. All the other senses are neglected. Some few train their hearing alone. Almost all agree to neglect smell and taste; while only the blind have their sense of touch properly trained. The truth is that man has not a single unnecessary sense, not one that should not be systematically trained. We have become accustomed to class people as those whose images are chiefly of the visual or the auditory type. In many things these two classes of persons are scarcely intelligible to each other, because their ideas do not rest on the same sensory experiences. To the one class, the world is one of sight; to the other, one of sound.

We agree with Binet[1] that the normal man is one who can form definite images from all the senses, who can recall almost equally well the odour, colour, and touch of a rose, the taste of whipped custard as well as the sound made in beating it. If this is the right view, many are but sawed-off specimens of human beings.

As a preliminary to mapping out the proper sensory training, it becomes a matter of importance to know whether the great man is one whose distinct images are not fettered to any one sense, or whether he is one to whom all the pathways of incoming sensations are attractive. An examination of the writings of the greatest author of all time, as well as of some others who

[1] *La Psychologie du Raisonnement.*

are pre-eminent, will be useful in deciding this point; for we are all apt to use those images which strike us most forcibly, in preference to others. We should take the most eminent men, for we might naturally expect that a commonplace person would be but a fraction of a man. If we find that all the senses appeal strongly to the master mind, it will also be plain that we in order to interpret him must cultivate all our senses. Unless there has been community of experience, the one cannot interpret the images of the other. We can interpret only so much as we can assimilate to something in our own line of experience.

Let us first consider the sense of smell, which some educators have been thoughtless enough to decry.

When Shakspere tries to convey an idea of the exquisite perfection of certain music, he appeals to the sense of smell:

> ". . . it came o'er my ear like the sweet sound
> That breathes upon a bank of violets,
> Stealing and giving odour."

When he describes the barge on which the most beautiful woman of all time came down the Nile, the sense of smell is called on to make the image complete:

> "Purple the sails, and so perfumed that
> The winds were lovesick with them."

When the vendor in the *Winter's Tale* wishes to make his wares attractive, he says:

> "Gloves as sweet as damask roses."

In that strong scene after the fitful fever of ambition had left Lady Macbeth, Shakspere shows her conscience at work:

> "Here's the smell of the blood still:
> All the perfumes of Arabia will not sweeten this little hand."

Perdita for her matchless garland speaks of:

> ". . . violets dim,
> But sweeter than the lids of Juno's eyes,
> Or Cytherea's breath."

The Ghost in *Hamlet* for a moment relieves the tension of the scene, when he says:

> "But, soft! methinks I scent the morning air."

When a beautiful flower sprang up from the spot where the life-blood of Adonis wet the earth, Shakspere says of Venus:

> "She bows her head, the new-sprung flower to smell,
> Comparing it to her Adonis' breath."

In the *Twelfth Night*, Viola thus voices her well-wishing: "Most excellent accomplished lady, the heavens rain odours on you!"

In *Pericles*, the characters say of the chest:

> "Soft! it smells most sweetly in my sense.
> A delicate odour,
> As ever hit my nostril."

Before that wonderful dirge song in *Cymbeline* is sung, Shakspere makes a mourner say:

> "With fairest flowers
> While summer lasts and I live here, Fidele,
> I'll sweeten thy sad grave: thou shalt not lack
> The flower that's like thy face, pale primrose, nor
> The azured harebell, like thy veins, no, nor
> The leaf of eglantine, whom not to slander,
> Out-sweetened not thy breath."

In a sonnet Shakspere says:

"The rose looks fair, but fairer we it deem
For that sweet odour which doth in it live.
The canker-blooms have full as deep a dye
As the perfumed tincture of the roses,
Hang on such thorns, and play as wantonly
When Summer's breath their masked buds discloses;
But, for their virtue only is their show,
They live unwoo'd and unrespected fade,
Die to themselves. Sweet roses do not so;
Of their sweet deaths are sweetest odours made."

Any student can find in Shakspere's works a throng of images which demand a cultivated sense of smell for their interpretation and full comprehension. Let us now pass to the next greatest name in English literature.

In Milton's *Arcades* we read:

"And early, ere the odorous breath of morn
Awakes the slumbering leaves."

The Spirit in *Comus* sings:

". . . there eternal summer dwells
And west winds with musky wing
About the cedarn alleys fling
Nard, and Cassia's balmy smells.
Iris there with humid bow
Waters the odorous banks."

In *Lycidas*, one of the first lyrical poems of all time, the best botanical critics, after much discussion of the following beautiful passage, have concluded that the flowers were chosen, not for their colours, but for their fragrance:

"Bring the rathe primrose that forsaken dies,
The tufted crow-toe, and pale jessamine,
The white pink, and the pansy freak'd with jet,

The glowing violet,
The musk-rose, and the well-attir'd woodbine,
With cowslips wan that hang the pensive head,
And every flower that sad embroidery wears;
Bid amaranthus all his beauty shed,
And daffodillies fill their cups with tears,
To strew the laureat hearse where Lycid lies."

Passages like these, which demand definite odour images to interpret them fully, are frequent in the poems which Milton wrote *before* he was blind. If his odour sense had not been cultivated while he was still young, we may be sure that his older and less plastic nerve cells would not have taken on the required modification after he was blind.

In the *Paradise Lost*, odour images are specially pronounced:

". . . Now gentle gales,
Fanning their odorif'rous wings, dispense
Native perfumes, and whisper whence they stole
Those balmy spoils. As when to them who sail
Beyond the Cape of Hope, and now are past
Mozambique, off at sea north-east winds blow
Sabean odours from the spicy shore
Of Araby the Blest; with such delay
Well pleased, they slack their course, and many a league
Cheer'd with the grateful smell old Ocean smiles."

The careful student of the fourth and the fifth books of the *Paradise Lost* can hardly fail to be impressed with the fact that odours enter to a remarkable degree into that wonderful picture of Eden:

". . . airs, vernal airs
Breathing the smell of field and grove, attune
The trembling leaves."

"Groves whose rich trees wept od'rous gums and balm."

Eve thus describes Eden without the companionship of Adam:

"... fragrant the fertile earth
After soft showers; and sweet the coming on
Of grateful ev'ning mild; then silent Night,
With this her solemn bird, and this fair Moon,
And these the gems of Heav'n, her starry train;
But neither breath of Morn, when she ascends
With charm of earliest birds; nor rising Sun
On this delightful land; nor herb, fruit, flower,
Glis'tring with dew; nor fragrance after showers;
Nor grateful ev'ning mild; nor silent Night
With this her solemn bird, nor walk by Moon,
Or glitt'ring starlight, without thee is sweet."

In the noble passage just quoted, with its wealth of olfactory, tactile, visual, auditory, and motor images, nothing is more pronounced than the fragrance which loads the air of Eden. The same is true of the following passage:

"Thus talking hand in hand, alone they pass'd
On to their blissful bow'r; it was a place
Chosen by the Sov'reign Planter, when he framed
All things to Man's delightful use. The roof
Of thickest covert was inwoven shade,
Laurel and myrtle, and what higher grew
Of firm and fragrant leaf: on either side
Acanthus, and each odorous bushy shrub
Fenced up the verdant wall . . .
. . . Here in close recess,
With flowers, garlands, and sweet-smelling herbs,
Espoused Eve deck'd first her nuptial bed."

Eve says of her ominous dream of the apple:

"... The pleasant sav'ry smell
So quicken'd appetite, that I, methought,
Could not but taste."

Adam withdraws her attention from this unpleasant dream by saying:

"... let us to our fresh employments rise
Among the groves, the fountains, and the flowers
That open now their choicest bosom'd smells."

"... So to the sylvan lodge
They come, that like Pomona's arbour smiled
With flow'rets deck'd and fragrant smells."

A beautiful line in Gray's *Elegy* will receive scant interpretation from those whose sense of smell has not been developed by experience such as he suggests:

"The breezy call of incense-breathing morn."

That child is fortunate who can definitely interpret this passage from Keats:

"... He arose
Ethereal, flush'd, and like a throbbing star
Seen mid the sapphire heaven's deep repose;
Into her dream he melted, as the rose
Blendeth its odour with the violet, —
Solution sweet."

We have quoted enough to show that, no matter what commonplace minds may think to the contrary, Shakspere and Milton thought odour images worthy to be used in their most noble and beautiful passages. Aside from the necessity of having a cultivated olfactory brain tract in order to assimilate the works of the greatest writers, it must be further remembered that things in nature have odour qualities. Exact information demands complete knowledge of a thing. All the senses must hand in their report before we can be said to know a thing.

The sense of taste is almost always combined with odour and touch. We know that much of the pleasure from eating jellies is due to tactile sensations in the tongue. The Shah of Persia reproached Europeans for the use of knives and forks, saying that the sense of taste began in the finger tips. This is to a certain extent true, and it had not escaped the penetrating mind of Shakspere. He makes one of his characters say:

> "Man's hand is not able to taste, his tongue to conceive, nor his heart to report, what my dream was."

Shakspere also has one of his characters say:

> "Mine eyes smell onions, I shall weep anon."

The fact that when the nose is held, many articles of food are well-nigh tasteless, shows that when we cultivate taste, we are really developing three senses at once. The images derived from the isolated sense of taste are, therefore, naturally not very numerous; yet every time the terms "sweet," "sour," or "bitter" are employed, their meaning finds its sole foundation in the experiences of the gustatory sense.

Ophelia in a touching passage appeals to the senses of both taste and sound to make her meaning clear:

> "And I, of ladies most deject and wretched,
> That sucked the honey of his music vows,
> Now see that noble and most sovereign reason,
> Like sweet bells jangled, out of tune and harsh."

When Cleopatra was beginning to sleep the sleep of death, she whispered:

> "As sweet as balm, as soft as air,"

and seeming thus to taste, as well as touch, the Lethean cup, she fell asleep.

Milton gives the sense of taste full prominence in his Eden:

"... to their supper-fruits they fell,
Nectarine fruits which the compliant boughs
Yielded them, side-long as they sat recline
On the soft downy bank damask'd with flow'rs.
The savoury pulp they chew, and in the rind
Still as they thirsted scoop the brimming stream."

"Others whose fruit burnished with golden rind
Hung amiable, Hesperian fables true,
If true, here only, and of delicious taste."

"And Eve within, due at her hour prepared
For dinner sav'ry fruits, of taste to please
True appetite, and not disrelish thirst
Of nect'rous draughts between, from milky stream,
Berry or grape."

"She turns, on hospitable thoughts intent
What choice to choose for delicacy best,
What order, so contrived as not to mix
Tastes not well joined, inelegant, but bring
Taste after taste upheld with kindliest change."

When Raphael visits the spotless pair in Eden, Eve prepares some of the delights of taste:

"... for drink, the grape
She crushes, inoffensive must, and meaths
From many a berry, and from sweet kernels press'd
She tempers dulcet creams."

When the sensory centre for taste has been well developed in the brain, there is an added pleasure in living. Life is not so rich in pleasures that one can be needlessly lopped off. The same viands, if enjoyed, are better digested than if they are not. The nerve pleasure coming from the proper exercise of physical taste is no more to be despised than any other pleasure which has its foundation in nervous action. When we grow older and the nerves of taste have become blunted, we may still have genuine enjoyment in recalling images of youthful gustatory pleasure in eating strawberries, peaches, or the viands prepared by maternal hands. Besides, taste furnishes a quality essential to the proper knowledge of many things. What sort of an object would a strawberry be, if it had never been tasted? That childhood must be very barren which furnishes no gustatory images for age to wonder at, and to enjoy in recalling. If we can remember some youthful experiences with honey, we shall certainly the better enjoy and understand these lines from Milton, where he addresses the flowers:

> "Throw hither all your quaint enamell'd eyes,
> That on the green turf suck the honied showers."

Memories of childhood may cause the face of the wearied city dweller to lighten up, as he reads in the *Tempest:*

> "Where the bee sucks, there suck I."

Fortunately, the sense of touch must be trained to a certain extent in order that we may use our eyes intelligently. We cannot say that a chestnut burr looks rough until we have felt it in connection with looking at it. Slowly, through many trials, we come to use the lights and shades and varying magnitudes as signs for ocular judgments, which have heretofore in similar cases been verified by an appeal to touch and muscular sensations. Notwithstanding this, the sense of touch of many persons is very imperfectly trained. It is by no means certain that it might not be better for most children to be blind a year or two early in life, so that more attention might be paid to training the sense of touch.

To show that Shakspere must have been capable of forming definite tactile images, we quote a few passages which can receive their complete interpretation only in the light of tactile experience :

> "There's a divinity that shapes our ends
> Rough hew them how we will."

> ". . . the female ivy so
> Enrings the barky fingers of the elm."

The rough hewing and the uneven bark on a tree must either be directly ascertained by touch or inferred from past tactile sensations.

When Charmion addressed the eyes of the dying Cleopatra :

> ". . . Downy windows close,"

she used an image from one of the most pleasing of tactile sensations, that of down.

> ". . . I take thy hand, this hand,
> As soft as doves' down and as white as it."

> ". . . O, that her hand,
> In whose comparison all whites are ink,
> Writing their own reproach, to whose soft seizure
> The cygnet's down is harsh, and spirit of sense
> Hard as the palm of ploughman."

> "Love's feeling is more soft and sensible
> Than are the tender horns of cockled snails."

Macbeth says to the dagger :

> ". . . Come, let me clutch thee.
> I have thee not, and yet I see thee still.
> Art thou not, fatal vision, sensible
> To feeling as to sight? or art thou but
> A dagger of the mind, a false creation?"

> ". . . the hand of little employment hath the daintier sense."

"Bow, stubborn knees: and, heart with strings of steel,
Be soft as sinews of the new-born babe!"

". . . Weariness
Can snore upon the flint, when resty sloth
Finds the down pillow hard."

". . . the silken tackle
Swells with the touches of those flower-like hands."

Ophelia, in replying to the good advice of Laertes, uses images which appeal most strongly to the sense of touch:

". . . But good my brother,
Do not as some ungracious pastors do,
Show me the steep and thorny way to heaven,
Whilst like a puff'd and reckless libertine
Himself the primrose path of dalliance treads."

The blinded Gloucester says of his son:

"Might I but live to see thee in my touch,
I'd say I had eyes again."

When Shakspere speaks of reclining on beds of lilies in Elysium, the sense of touch is even more strongly appealed to than the sense of odour.

In Milton's *Comus* the river goddess says:

"Thus I set my printless feet
O'er the cowslip's velvet head,
That bends not as I tread."

Now, the head of a cowslip cannot have "velvet" applied to it except in terms of touch.

Milton also speaks of

"Beds of hyacinths and roses,
Where young Adonis oft reposes,
Waxing well of his deep wound,
In slumber soft."

Adam and Eve recline

> "On the soft downy bank, damask'd with flow'rs."

Under what are popularly termed sensations of touch, are included muscular, pressure, and temperature sensations. Shakspere appeals to all these, and, in order to follow him, we must be able to recall definite images based on our own experience. Macbeth awakens such images in our minds, when he says:

> "Life's but a walking shadow, a poor player
> That struts and frets his hour upon the stage,
> And then is heard no more."

It is well to notice that if we form definite images of Hamlet's behaviour with Ophelia, as we read these lines, we must appeal to former muscular sensations:

> "At last, a little shaking of mine arm
> And thrice his head thus waving up and down,
> He raised a sigh so piteous and profound
> As it did seem to shatter all his bulk
> And end his being."

Shakspere also frequently appeals to the temperature sense, which experiment has shown to depend on nerves other than those of touch. The following passages appeal to the temperature sense:

> "Freeze, freeze, thou bitter sky,
> That dost not bite so nigh
> As benefits forgot;
> Though thou the waters warp,
> Thy sting is not so sharp
> As friend remembered not."

> "A milk-sop, one that never in his life
> Felt so much cold as over shoes in snow."

"My hour is almost come
When I to sulphurous and tormenting flames
Must render up myself."

"O, who can hold a fire in his hand
By thinking on the frosty Caucasus?
Or cloy the hungry edge of appetite
By bare imagination of a feast?
Or wallow naked in December snow
By thinking on fantastic summer's heat?"

Auditory images are employed by Shakspere frequently to give warmth and vigour to his scenes.

In the *Winter's Tale*, Autolycus sings:

"The lark, that tirra-lirra chants,—
With heigh! with heigh! the thrush and the jay,
Are summer songs for me and my aunts,
While we lie tumbling in the hay."

Some of the most exquisite passages in the *Merchant of Venice* contain auditory images:

"Let music sound while he doth make his choice;
Then, if he lose, he makes a swan-like end,
Fading in music."

"How sweet the moonlight sleeps upon this bank!
Here will we sit and let the sounds of music
Creep in our ears: soft stillness and the night
Become the touches of sweet harmony."

"The man that hath no music in himself,
Nor is not moved with concord of sweet sounds,
Is fit for treasons, stratagems, and spoils."

The *Midsummer Night's Dream* brings in the sounds of the fields:

> ". . . Your tongue's sweet air
> More tunable than lark to shepherd's ear
> When wheat is green, when hawthorn buds appear."

When Orlando wishes to move some strangers with pity over his condition, the first concrete image that he employs is an auditory one:

> "If ever you have look'd on better days,
> If ever been where bells have knoll'd to church."

Some of the sweetest songs in his plays are resonant with auditory images:

> "Under the greenwood tree
> Who loves to lie with me,
> And tune his merry note
> Unto the sweet bird's throat."

> "When shepherds pipe on oaten straws
> And merry larks are ploughmen's clocks."

When Milton in his youth was moving among rare country scenes at Horton, his world was as much auditory as visual. These auditory images appear in his poetry:

> "Oft listening how the hounds and horn
> Cheerily rouse the slumbering Morn
> From the side of some hoar hill,
> Through the high wood echoing shrill.
>
> * * * * * * *
>
> "While the ploughman near at hand
> Whistles o'er the furrow'd land
> And the milkmaid singeth blithe
> And the mower whets his scythe.
>
> * * * * * * *

"While the bee with honied thigh
That at her flowery work doth sing,
And the waters murmuring,
With such consort as they keep,
Entice the dewy-feather'd sleep."

His *Hymn on the Nativity* abounds in auditory images. In his *Comus* one of the characters says:

". . . might we but hear
The folded flocks penn'd in their wattled cotes,
Or sound of pastoral reed with oaten stops,
Or whistle from the lodge, or village cock
Count the night watches to his feathery dames.

* * * * * * * * *

"At last a soft and solemn breathing sound
Rose like a steam of rich distill'd perfumes,
And stole upon the air. . .
. . . I was all ear
And took in strains that might create a soul
Under the ribs of Death."

Though the *Paradise Lost* has many auditory images, we shall not quote from it because Milton was blind when he wrote it. Hence, it might be claimed that he was then driven to auditory images, but it must not be forgotten that he could only be driven to use his youthful acquisitions. All the above quotations embodying auditory images are taken from his writings before he was thirty.

Wordsworth gives us perhaps as pure an auditory image as is to be met with in literature:

"O cuckoo! shall I call thee bird
Or but a wandering voice?"

It is scarcely necessary to show that the greatest writers employ visual images. The eye is frequently the only sense organ that receives anything like adequate cultivation. The one who can draw his images from this sense alone, resembles a paralytic, who has lost control over all his limbs but one. Since there are a few great persons whose visual images are deficient, and who employ chiefly auditory images, we shall quote a few lines from Shakspere and Milton to show that they are not of this type.

Visual images are necessary to interpret Shakspere, when he speaks of the liveries of autumn, the freckles of the cowslip, the bolted snow, the greenwood tree, the roses fading in Hermia's cheeks, the

> " . . . little western flower,
> Before milk white, now purple with love's wound."

The colours mentioned in the following amusing passage from *A Midsummer Night's Dream* can be interpreted in terms of vision alone:

> " Asleep, my love?
> What, dead, my dove?
> O Pyramus, arise!
> Speak, speak. Quite dumb?
> Dead, dead? A tomb
> Must cover thy sweet eyes.
> These lily lips,
> This cherry nose,
> These yellow cowslip cheeks,
> Are gone, are gone:
> Lovers, make moan,
> His eyes were green as leeks.
> O Sisters Three,
> Come, come to me,
> With hands as pale as milk;

Lay them in gore
Since you have shore
With shears his thread of silk."

The same drama teems with visual images, which a person who has trained his senses sufficiently well on the proper natural objects, could form distinctly enough for a picture to be painted from them :

"The cowslips tall her pensioners be;
In their gold coats spots you see, —
These be rubies, fairy favours,
In those freckles live their savours.
I must go seek some dewdrops here,
And hang a pearl in every cowslip's ear."

We shall here note only a few of the visual images which Milton employed after he was blind :

"Ye Mists and Exhalations that now rise
From hill or steaming lake, dusky or gray
Till the Sun paint your fleecy skirts with gold."

* * * * * * * *

"Girt like a starry zone his waist, and round
Skirted his loins and thighs with downy gold
And colours dipt in Heav'n."

"Innumerable as the stars of night,
Or stars of morning, dewdrops, which the Sun
Impearls on ev'ry leaf and ev'ry flow'r."

"Now Morn her rosy steps in th' eastern clime
Advancing, sow'd the earth with orient pearl."

"A broad and ample road, whose dust is gold,
And pavement stars, as stars to thee appear
Seen in the galaxy, that milky way,
Which nightly as a circling zone thou seest
Powder'd with stars."

Shakspere in his greatest character speaks contemptuously of those who rely on only one sense:

> "Eyes without feeling, feeling without sight,
> Ears without hands or eyes, smelling sans all,
> Or but a sickly part of one true sense
> Could not so mope."

Even Christopher Sly the tinker has sense enough to say, on awaking and finding himself in a changed place:

> ". . . I see, I hear, I speak;
> I smell sweet savours and I feel soft things."

Again and again does Shakspere invest every sense with the royal purple. Now one and now the other seems his favourite child. Of him it may be said in the language of one of his characters:

> ". . . The five best senses
> Acknowledge thee their patron; and come freely
> To gratulate thy plenteous bosom: th' ear,
> Taste, touch, and smell, pleased from thy table rise;
> They only now come but to feast thine eyes."

We have already quoted enough to show that the greatest writers of all time had definite images from every sense. They despised none, neither taste nor smell. Even Shakspere did not shrink from making the beautiful princess Perdita

> "The queen of curds and cream."

We intended in this chapter to show that the world appealed to all the senses, that in order to know it definitely and to enjoy it fully, we could not afford to overlook the training of any sense. We also started with the supposition that the most perfect specimen of man would have a marked preference for neither visual nor auditory images, but all the avenues of sense would be attractive to him; that to call a man a visualist or an *auditaire* is to accuse him of being one-sided. An examination of Shakspere's and of Milton's writings confirms this view. When we keep our children confined with books away from the odour of the wild flowers, the touch of the velvet grass, the taste of the wild berry, the song of the birds, or the sight of the daisy, we may know that this almost exclusively bookish training would have silenced the master singer of all time.

CHAPTER VIII

Special Sensory Training

The greatest mistake made in education consists in shutting children away from nature, and in trying to teach them almost entirely from books. In the majority of cases, children at the age of six or eight still go to school to study books. When we remember that the different sensory centres in the brain remain plastic but a comparatively short time, we can see how *much of the education of the day actually causes the sensory cells to atrophy*. Since the highest forms of knowledge rest on a sensory foundation and can never be any firmer than that foundation, we can realize that even the metaphysician is not in a position to decry sense training.

Some have said that a child ought, as a matter of course, to be put to studying books on entering school, since enough time has already been given for developing the senses. The kindergarten has undoubtedly taken an important step in the direction of properly training the senses, but we must not forget that only one step has been taken. The first letter in the alphabet of sense training has been taught by the kindergarten, and in many cases well taught. The very damaging impression has become common with many teachers that the child should have graduated in sense training on leaving the kindergarten. Sense training ought to be continuous and methodical until at least the age of twenty. In those ages when there were few books, the ages when Chaucer, Dante, and Shakspere lived, the training of the senses continued the entire life. Instead of reading about a thing, men studied it with their own senses.

In Boston and Kansas City, questions have been given to children on entering school, to determine the extent and accuracy of their ideas. Those who think a child's senses are then sufficiently well-cultivated for him to study thereafter mostly

Name of Object or Conception.	Per Cent of Children Ignorant of it.		
	In Boston.	In Kansas City.	
		White.	Colored.
Beehive	80.0	59.4	66.0
Crow	77.0	47.3	59.0
Ant	66.5	21.5	19.1
Squirrel	63.0	15.0	4.2
Robin	60.5	30.6	10.2
Sheep	54.0	3.5	0.0
Bee	52.0	7.27	4.2
Frog	50.0	2.7	0.0
Pig	47.5	1.7	0.0
Chicken	35.5	0.5	0.0
Worm	22.0	0.5	0.0
Butterfly	20.5	0.5	0.0
Hen	19.0	0.1	0.0
Cow	18.5	5.2	0.0
Growing wheat	92.5	23.4	66.0
Elm tree	91.5	52.4	89.8
Oak	87.0	66.2	58.6
Pine	87.0	65.6	87.2
Maple	83.0	31.2	80.8
Growing moss	81.5	30.7	42.5
Growing strawberries	78.5	26.5	1.1
Dew	78.0	39.1	70.2

from the printed page, must receive something of a shock on reading the figures given above. It should be noted that the percentages indicate, not the number possessing the concept, but those *ignorant* of it. The majority of the children were about six years old.

This report[1] shows that seventy-eight per cent of Boston children would not know what the sparkling dew was. In after years these children could scarcely be expected to attach much meaning to Shakspere, when his fairy spoke of hanging a pearl in every cowslip's ear.

The very first step towards cultivating a child's senses consists in putting him in as favourable an environment as possible. It is nonsense to expect to have well-cultivated senses in children who live in crowded tenements. Dr. Hall says: "The best preparation parents can give their children for good school training is to make them acquainted with natural objects, especially with the sights and sounds of the country. . . .

"As our methods of teaching grow natural, we realize that city life is unnatural, and that those who grow up without knowing the country are defrauded of that without which childhood can never be complete or normal. On the whole, the material of the city is no doubt inferior in pedagogic value to country experience. A few days in the country at this age has raised the level of many a city child's intelligence more than a term or two of school training could do without it. . . .

"On the whole, however, additional force seems thus given to the argument for excursions by rail or otherwise, regularly provided for the poorer children, who are causing the race to degenerate in the great centres of population, unfavourable enough for those with good homes or even for adults."[2]

[1] By G. S. Hall and J. M. Greenwood.

[2] G. Stanley Hall's *The Contents of Children's Minds*, pp. 26, 28, 30.

But it is not enough for the children to be taken into the country. As Whittier says, the parent or the teacher must himself first know:

> "Knowledge never learned of schools,
> Of the wild bee's morning chase,
> Of the wild flower's time and place,
> Flight of fowl and habitude
> Of the tenants of the wood;
> How the tortoise bears his shell,
> How the woodchuck digs his cell
> And the groundmole sinks his well;
> How the oriole's nest is hung;
> Where the whitest lilies blow,
> Where the freshest berries grow,
> Where the ground-nut trails its vine,
> Where the wood grape's clusters shine;
> Of the black wasp's cunning way,
> Mason of his walls of clay,
> And the architectural plans
> Of gray hornet artisans!"

If the child's knowledge reaches to a solid foundation of sense training like this, the floods of time will beat in vain upon that knowledge. Other things may pass away, but that remains while the brain lasts.

Teachers of English literature are complaining that pupils cannot understand or appreciate some of the most beautiful, as well as the most simple, things because of the lack of sense training. For instance, from Gray's *Elegy:*

> "The breezy call of incense-breathing morn,
> The swallow twitt'ring from the straw-built shed,
> The cock's shrill clarion or the echoing horn,
> No more shall rouse them from their lowly bed."

In order to interpret this simple stanza, there must be formed an olfactory image of the fragrance of a rural morning; auditory images of the twittering of the swallow, the crowing of the rooster, the melodious echoes of a horn; visual images of the swallow, the straw-built shed, the rooster, and the horn. Here are eight special sense images demanded in order that we may interpret what would be otherwise meaningless marks on paper. Here is also a good chance for the reader to test the accuracy and definiteness of his early sense impressions. He, and only he, can tell whether they are definite or hazy. These eight objects are probably as good to train the senses with as any other eight that could be named. Every poetical quotation in the preceding chapter presents sense objects which indicate the direction for special training. Let these passages be read with the express purpose of forming the images therein suggested. If no definite images are forthcoming to interpret certain objects, let the senses search them out and receive training therefrom.

If the teacher of literature complains of the inability of pupils to interpret the simple sensory images of the poets, what shall the scientist say? How can his pupils have anything but a hazy foundation for their unsafe generalizations? A thing is a compound of the qualities furnished by *all* the senses. If any special sense fails to do its duty because of lack of training, knowledge must to that extent be imperfect. The time will come when it will seem as stupid, nay, as criminal, to neglect the proper training of all a child's senses as to fail to teach him to read.

To indicate how the different sensory brain tracts are to be trained is an extremely simple thing. Suppose some one were to ask, "How can I modify the surface of a photographic plate by means of a pine tree?" There can be but one reply, "Take the properly prepared camera where there is a pine tree, and raise the slide." A picture of the tree will then develop on the plate. In the case of senses, we have impressible brain cells in place of the plate. It is, however, necessary to go where the object can affect the senses. We must go where we can see the pine tree, hear the wind sighing through its branches, touch its rough bark, the exuding pitch, or the needle-like leaves, and catch whiffs of the balsamic odour.

The first step in training the sensory centres is, therefore, seen to consist in bringing them where stimuli from the appropriate natural objects can act on them. The stimuli from these various objects will be transmitted by the proper sensory nerves to certain parts of the brain. The nerve cells will retain after a fashion of their own the modifications due to these stimuli, just as the photographic plate preserves the changes made by light. Suppose a modification corresponding to the odour of the honeysuckle is desired. The olfactory nerves must be brought where the fragrance can impress them and transmit its stimulation to those nerve cells in the front part of the subtemporal region. The mere play of this stimulus upon those cells will tend to direct there an increased blood supply. Better nutrition will follow as a consequence of this, as well as all the other advantages which come with the proper exercise. If the song of the robin or the bluebird is desired to be known, we must simply go where it can be heard. No course of abstract reasoning will then be required to enable the stimulus to pour along the auditory nerves to the cells in the temporal lobes of the brain and to give them that peculiar modification which can result only from the song of the robin or the bluebird.

If parents and teachers would merely expose their children to such stimuli, cerebral modification and reaction would certainly take place without the necessity for constant worry or supervision. Much of the resulting good might thus be unconsciously obtained, but it would be neither the worse nor the less permanent for that. The ascetic may dislike to see the little prattler unconsciously played on by the grand stimuli of nature. The ascetic may wish that all improvement came as the result of tears, groans, and the hard processes of abstract thought. But in spite of him, much of our improvement or deterioration comes unconsciously. Emerson understood the beneficial effect of natural stimuli exerting an unconscious influence when he wrote: "The poet, the orator bred in the woods, whose senses have been nurtured by their fair and appeasing changes, year after year, *without design or heed*, shall not lose their lessons in the roar of cities and the broil of politics. Long hereafter, amid agitation and terror in national councils, these solemn images shall reappear in their morning lustre, as fit symbols for the language of the hour. At the call of a noble sentiment, again the woods wave, the pines murmur, the river rolls and shines, and the cattle low upon the mountains, putting the spells of persuasion, the keys of power, into his hands."

While sensations from natural objects are certain to modify the central nerve cells without outside intervention or explanation, it is true that children's senses will be far better cultivated if they are so fortunate as to have a good observer direct their attention to the proper things and to the most worthy qualities in those things. The same photographic apparatus will do far better work in the hands of a man who knows how to focus and adjust it properly. A good parent or teacher stands in precisely the same relation to the nerve apparatus of a child. Attention is the focus of consciousness, and the one who can adjust the child's attention properly has thereby put him in the only royal road to the most perfect development.

There are few good cultivators of the senses to-day, for the reason that few teachers had their own senses well trained while young. For many years sense training has been theoretically commended and practically discouraged. They lay themselves open to a peculiar charge, who insist that all knowledge has its foundation in the senses, and who yet see that almost all a child's time allotted to study is taken up with poring over books. In a certain city a good observer not long ago on a bright spring morning took an entire class from the dingy school-building into the fields, where the flowers were starting and the birds singing. He was severely criticised by some school officials and parents, who said: "The children ought to have been studying their books and learning something instead of running around and wasting their time in that way!" Such sages ought to ponder truths like these: "Lazarus shows that by far the greatest number of Roman authors who afterwards attained celebrity were not born in Rome itself; he thinks the cause of their greatness may be found in the impressions of their early youth; the child in the country has simpler but oft-repeated impressions; hence they endure longer and the psychical actions become more concentrated, while the rapidly changing and varying impressions of the metropolis are more volatile, remain a less time themselves, and yet render the inner concentration more difficult."[1]

The study of books will be much easier later in life if the senses have first been well trained. When reading a play of Shakspere or a chapter of Ruskin, we notice that the

[1] Radestock's *Habit in Education*, p. 57.

reading is both pleasant and rapid if we can, as we read, form interpretative images based on our own experience. On the other hand, it is never easy to train the senses after twenty. Dr. Karl Langė has come to the conclusion that the knowledge which a well-trained child of six has acquired, surpasses in value the acquisitions of any student during his university period.

The fact that certain sensory tracts in the brains of those who are early deprived of some sense do not fully develop is certainly important enough to cause us to train to the best of our ability all the senses of the young. The practical question then confronts us: How shall we best develop every sensory brain tract while it is still plastic?

Before we proceed to answer this question specifically, we must consider the objections of those who say that it is perfectly proper that one sense should be well developed while the rest are not, — that we need our piano-tuners, artists, perfumers, tea-tasters, and that these must have one sense developed at the expense of others. Again, these objectors say that some children are born with certain sensory tracts well developed and with others that no amount of training will raise to the first rank.

We grant that the conditions of life are frequently such that one sense must be used more than another and hence be better developed. We also grant that some who will make the great musicians of the future may have at birth a brain that will lend itself better to auditory than to visual development. We fail, however, to recognize any argument in the mere assertion that if any one has naturally a weak left arm he should therefore neglect to exercise it. The mere fact that any portion of the body or any function is weak is in itself an argument for judicious exercise in that direction.

Some persons think that after they have discovered that a child has a better memory for things heard than for things seen, his future sensory training ought to be mainly auditory. Of course, advantage should be taken of hereditary natural capacity, but even this will improve in a healthier way if the other powers are developed at the same time. This world is not made up exclusively of either sight or sound phenomena. Hence a large part of it must be lost to the one trained in a one-sided way. Such a one will not be able to apperceive things outside of his own narrow sphere. They will have no meaning for him, because he has never paid attention to their relations to other things. The claim that the senses of a child should be trained only in the direction of what is to be his chief work is as untenable as the assertion that a child intending to become a physician should at once be put to studying anatomy and the pharmacopœia, and should not first have a university education. Any specialists trained in this way will perform their work without broad insight into its important relations with other things.

It is further probable that as the sensory cells grow stronger through exercise, more associative fibres lead from them to other parts of the brain. Hence, lack of exercise may cause not only undeveloped cells but also a diminished number of associative fibers. Even such second-rate brain cells might thus be at a further disadvantage by being poorly associated with each other. Such a brain could, of course, never fully use in combination what powers it possessed. Professor Donaldson rightly says: "We should hardly expect much appreciation of colour in a person brought up in the dark, however good his natural endowments in this direction. Thus any lack of early experience may leave a spot permanently undeveloped in the central system — a condition of much significance, for each locality in the cerebrum is not only a place at which reactions, using the word in a narrow sense, may occur, but by way of it pass fibres having more distant connections, and its lack of development probably reduces the associative value of these also."[1]

The first practical rule for the development of the different sensory areas in the brain may be thus formulated: Put the brain in such an environment that the fitting stimulus may flow along the proper sense nerve to the cells in the related brain tract. Our present task must be to determine what objects in nature afford the best stimuli for the different sensory areas. Before the child is old enough to reason or to know our aim definitely, we can expose him to these stimuli.

Objects for Cultivating the Olfactory Sense

We have seen that Shakspere and Milton used many odour images, and that these great men were exposed to an environment which allowed the development of the sense of smell. The odours of the country are the best for cultivating the olfactory sense. For those who live chiefly in the city, as well as for all in the winter time, it is easy to obtain from an apothecary small boxes of different objects with which to cultivate the sense of smell. For his own experiments the writer procured at small cost pasteboard boxes filled with the following named substances. Pupils should be blindfolded while undergoing the tests:

Pennyroyal	Caraway	Gum benzoin
Sage	Chamomile	Valerian root
Orris root	Black pepper	Olibanum
Cinnamon	Red pepper	Ginger root
Cloves	Celery seed	Gum turpentine

[1] *The Growth of the Brain*, p. 348.

Licorice	Fennel	Assafœtida
Sassafras	Saffron	Myrrh
Allspice	Lavender flowers	Star anise
Cardamom	Gum opium	Tonka bean
	Manna	

The following named oils and perfumes were placed in small bottles:

Oil of peppermint	Oil of bay leaves	Oil of bergamot
Oil of clove	Oil of rosemary	Oil of spearmint
Oil of wintergreen	Oil of citronella	Oil of patchouly
Oil of cedar	Oil of verbena	Oil of bitter almonds
Oil of lemon	Oil of nutmeg	Oil of eucalyptus
	Oil of lavender	

The finest olfactory training is to be obtained from these flowers in their native habitat:

Goldenrod	Orange flowers	Lily of the valley
Majoram	Elder flowers	Heliotrope
Rosemary	Jasmine	Carnation
Honeysuckle	Tuberose	Geranium
Clover	Violet	Rose
Daisy	Hyacinth	Sweet pea
Tansy	Lilac	Blossoms of the peach and apple

In the winter time, perfumes from nearly all these flowers are obtainable, but there is no other place that can compare with the country in the summer for training the sense of smell. A little practice will enable most people, when blindfolded, to identify by the odour alone such fruits as the apple, pear, grape, peach, orange, lemon, plum, strawberry, and pineapple.

Objects for Gustatory Training

We herewith give a number of easily accessible foods and flavours for training the sense of taste. This sense demands more cultivation than it has usually received. A discriminating sense of taste makes us more interested in what we eat. This reacts upon the cookery and makes that better. Of extreme importance is the fact that those who are interested in what they eat, usually eat slowly, masticate their food well, and endeavour to have the viands yield their utmost flavour. The digestion of such persons will be better than of those who hurriedly bolt their food, scarcely noticing the different flavours. We can investigate in another chapter whether those ascetics are right who maintain that it is wicked or gross to take pleasure from the taste of a strawberry or a peach because the pleasure is not sufficiently "immaterial" or sublimated.

The sense of taste, as we ordinarily have it, is a resultant of three different senses, — smell, touch, and taste. There is certainly no harm in developing the three senses together, any more than there is in exercising the legs and arms at the same time. But if we wish to cultivate the sense of taste by itself as much as possible, the pupil must be blindfolded, his nostrils stopped, or a bottle of perfumery held under them. We shall then find mistakes made in identifying such common edibles as lamb, veal, duck, chicken, and beef. Of course touch is always present to assist the identifications of taste. Much of the pleasure from eating jelly is due to the delicate touch sensations awakened in the tongue.

It will be best at first for pupils to be blindfolded and taught to distinguish with unerring precision between the edibles named below. They should in every instance be put into the pupils' mouths by another person. In the case of fruits like strawberries, cherries, blackberries, or grapes, we must cut them up into slices before they are laid on the tongue, or otherwise the object will be more easily identified by its shape than by the taste. These edibles must not be tasted in too quick succession, for the nerves of taste retain for some time the effects of stimulation from any one viand. Neither must the exercises be continued too long, for all nerve cells soon show the effects of fatigue due to continuous stimulation.

Strawberry	Cranberry	Tea
Grape	Citron	Coffee
Apple	Plum	Chocolate
Pear	Raisin	Rhubarb
Peach	Vanilla	Ginger
Orange	Wintergreen	Honey
Lemon	Peppermint	Sugar
Quince	Spearmint	Salt
Blackberry	Sassafras	Veal
Cherry	Catnip	Venison
Pineapple	Fennel	Lamb
Banana	Caraway	Chicken
Raspberry	Sage	Duck
Currant	Cinnamon	Goose
Gooseberry	Clove	Quail
	Nutmeg	

These lines from Keats appeal for interpretation most strongly to the sense of taste, and they indicate additional objects for sense discrimination:

"... he from forth the closet brought a heap
Of candied apple, quince and plum, and gourd;
With jellies soother than the creamy curd,
And lucent syrops, tinct with cinnamon;
Manna and dates, in argosy transferr'd
From Fez; and spiced dainties, every one,
From silken Samarcand to cedar'd Lebanon."

Objects for Cultivating the Sense of Touch

It has been said that the blind alone have their tactile sense adequately cultivated. This neglect is certainly not from lack of the proper tactile material, for it is hard work to avoid this. Everything, from the sides of the infant's cradle to the toys with which he begins to play, cultivates the sense of touch. While we may grant that our bookish education tends toward imperfect cultivation of all the senses, it is probable that touch is generally the best educated of all. This may almost be called the foundation sense for sight. When, on looking at a piece of cloth, we say that it has a very rough nap, we are basing our conclusions on past sensations of touch. But for these, sight would be powerless to tell us whether a surface that looked that way would feel rough.

We need mention here only a few of the numberless things that we can handle, only such as may prove most serviceable for cultivating refinement of touch. The pupil should be blindfolded and asked to identify the following named articles:

Silk	Dandelion down	Grape
Velvet	Feathers	Plum
Wool	Clover	Currant
Linen	Pear	Cranberry
Cotton	Quince	Blackberry
Hemp	Apple	Strawberry
Flax	Peach	Raspberry

After these objects can be surely named from touching them, it is fine practice to study the leaves of the more common forest trees with the aid of both the eye and the hand. After the leaves are familiarly known by the aid of both the senses, the pupil should be blindfolded and asked to identify by touch the leaves of the elm, maple, chestnut, hickory, black walnut, oak, dogwood, birch, beech, sycamore, willow, pine, larch, hemlock, cedar, and whatever other trees are found in the neighbourhood. The leaves of flowers and plants may also be treated in the same way. It also requires considerable nicety of touch to distinguish between the heads of wheat, rye, and barley. Of course any article about the house, from a water pitcher to a spool of silk, can be brought to a blindfolded child to name by the combined tactile, thermal, and muscular senses.

Sounds for Developing the Auditory Tract

We shall here enumerate some of the more common sounds, which may be brought to play on the auditory brain tracts. Here, as before, the country is demanded for environment during a portion of the year.

Song of the robin
Song of the catbird
Song of the thrush
Song of the oriole
Song of the bluebird
Song of the mocking-bird
Song of the swallow
Song of the blackbird
Song of the magpie

Drumming of woodpeckers
Cawing of crows
Cackling of fowl
Crowing of roosters
Quacking of ducks
Cry of owl
Honking of geese

Bleating of lambs
Neighing of horses
Lowing of kine
Barking of dogs
Chirping of crickets
Hum of bees

Ringing of church bells
Sound of Æolian harp
Sound of piano
Sound of violin
Sound of organ
Sound of flute
Sound of drum
Sound of bagpipe
Sound of huntsman's horn
Sound of harp
Sound of orchestral music

Sound of the wind among the pine trees
Rustling of leaves
Sound of running water
Sound of the waves
Songs in varying key
Beating of rain against the window panes
Various noises made by the wind

Objects for Visual Training

The objects that appeal to sight, and hence exercise and develop the visual brain tract, are so numerous that it is not necessary to specify them at any great length. The vast majority of objects appeal to sight; only a comparatively few to hearing, taste, or smell. In this class we may put natural objects ranging from a cloud to a leaf, from a star to a stone. We shall, therefore, mention only a few of the many objects upon which sight may be trained.

All the common wild flowers, from the daisy to the dandelion
Garden flowers
The shape of the leaves of all the most common trees
Various grasses
Colour and form of the birds
Colour and shape of the clouds
Colour and shape of the different fruits
The rainbow
Autumnal tints
Frost
Stars
Moon
Human faces
Animals
Snowflakes
Coloured ribbons, garments
Paints
Colour of eyes, of hair
Birds' nests and eggs

The importance of this special training of each sensory brain tract while it is most plastic should neither be overlooked nor despised. Every one of the masters among men has had his senses trained either consciously or unconsciously by natural objects such as we have indicated. We pick up a biography at random, for instance, that of Robert Browning, and read: "It is interesting to know that many of the nature touches were indirectly due to the poet's solitary rambles, by dawn, sundown, and 'dewy eve' in the wooded districts south of Dulwich at Hatcham and upon Wimbledon Common, whither he was often wont to wander and to ramble for hours. . . .

"I have heard him say that his faculty of observation at that time would not have appeared despicable to a Seminole or an Iroquois: he saw and watched everything, the bird on the wing, the snail dragging its shell up the pendulous woodbine, the bee adding to his golden treasure as he swung in the bells of the campanula, the green fly darting hither and thither like an animated seedling, the spider weaving her gossamer from twig to twig, the woodpecker heedfully scrutinizing the lichen on the gnarled oak-bole, the passage of the wind through leaves or across grass, the motions and the shadows of the clouds, and so forth. . . . He never forgot the bygone sunsets and great stars he saw in those days of his fervid youth. Browning remarked once that the romance of his life was in his own soul; and on another occasion I heard him smilingly add, to some one's vague assertion that in Italy only was there any romance left, 'Ah, well, I would like to include poor old Camberwell.'" Browning thought that romance still clung to his birthplace only because his youth was trained there in the right way.

Burroughs says of Tennyson: "A lady told me that she was once walking with him in the fields when they came to a spring that bubbled up through shifting sands in a very pretty manner, and Tennyson, in order to see exactly how the spring behaved, got down on his hands and knees and peered a long time into the water. The incident is worth repeating as showing how intently a great poet studies nature." After knowing this, we need not be surprised to meet with such a perfect simile as this in Tennyson's poetry:

> ". . . arms on which the standing muscle sloped,
> As slopes a wild brook o'er a little stone,
> Running too vehemently to break upon it."

The next century will probably see a marked reformation in education, especially in teaching the child more from the book of nature than from the printed page.

CHAPTER IX

Cerebral Development by the Formation of Images

To have the various sensory stimuli pouring into the brain is but one-half the battle in modifying the central nervous system. In order to render this modification more definite and lasting, images of these various stimuli must be recalled. For instance, after a rose has been seen, its visual appearance, odour, and softness to the sense of touch should be recalled. A successful recall helps to modify the brain in the same way that the original stimulus did. This truth has received scant appreciation, even by physiological psychologists, in the training of the young.

In order to understand the importance of recalling sensory stimuli, the physical basis of memory must be known. Let *A* be a brain cell or tract which receives the modification due to seeing a rose. When the visual image of the rose is recalled, there is action in precisely this same tract. There is no absolute line of demarcation between the action in this tract, when the sensory stimulus pours directly in, and the action resulting from recalling this experience. For our purpose, we may call attention to a difference which usually exists. The presence of an actual object to a sense organ generally causes more intense action in the related brain cells than the internal revival does. If we are looking at an actual orange, certain brain cells are usually set in more vigorous action than when we recall the image of the orange. One of the ways by which we decide whether the action in the brain cells does or does not correspond to a real object is by the intensity of that action. If the action were of equal intensity in both cases, we should have an illusion, that is, think we saw an orange where none existed.[1] In the case of sane persons, these illusions are by no means infrequent. If we have thought intensely about a certain thing, or if our mind is filled with images of it, we often think we see it when we do not. We often hear some one say, "I thought I was positive I saw a certain person or thing in a certain place. I cannot for the life of me understand how I came to be so mistaken."

It has been for some time noticed that the most honest men when playing lawn tennis often see the ball strike some inches away from the spot of actual contact. "He is honest when he is not playing tennis," was said of such a man. The fact was that the man meant to be honest at all times, but when he saw the ball taking a certain direction, he sometimes projected the image ahead of the ball and saw it strike in an advantageous position.

There is scarcely any difference of opinion among experts over the fact that images are correlated with activity in brain cells, and that this activity tends toward further brain modification. Ribot puts the case definitely: "If, with closed eyes, we keep for a length of time an image of very lively colours before the imagination, and then opening the eyes suddenly we fix them upon a white surface, we see thereon for an instant the image contemplated in imagination, but in the complementary colour. This fact, as is observed by Wundt, from whom we borrow it, proves that the nerve action is the same in the two cases — in the sense-perception and in the

[1] See Halleck's *Psychology and Psychic Culture*, pp. 108, 109.

memory."[1] Wundt has lately shown that the activity in these central cells may flow out and affect the sense organs themselves. He says: "The same sensations may be perceived, though less clearly, to accompany memorial ideation, at least when the ideas are vivid. An object seen with the mind's eye is referred to a certain distance from us, and we consequently accommodate the muscular apparatus of our eye to it. The tones of a melody which we recall in memory may give rise to a tension in the ear as clearly perceptible as though they were real. Even the fainter pictorial ideas which constitute abstract thinking are not wholly without the sense-accompaniment."[2] Ladd speaks to the same effect: "The recurrence of any memory image is, therefore, significant of the continuance of the effects of previous reactions to stimulation, in the shape of a tendency of the same nervous substance to react in ways similar to those in which it has formerly acted. . . .

"It is assumed that the *cortical centres concerned in sensation and in ideation are the same, for the same objects at least;* and this assumption is confirmed by all which we know of the physiology of the brain. . . .

"The cerebral processes which underlie sensation are *like* those which underlie image-making, in that similar changes in the same connected groups of nervous elements form the physical basis for both kinds of psychosis. . . . By increasing the intensity of revived central processes, more or less of hallucination may take place; and, finally, the mental image may become so like the sensations which it represents as to be with difficulty or not at all distinguished from them."[3]

The fact that the energy generated by these centrally initi-

[1] *Diseases of Memory*, Chap. I.

[2] *Lectures on Human and Animal Psychology*, p. 247.

[3] *Psychology*, pp. 241, 242.

ated images tends to flow out and affect the body can be demonstrated in many ways. Form a vivid idea of a file being drawn across your teeth, or of the dentist's drill being rapidly whirled around in a cavity, and notice the shiver that will sometimes affect the whole frame. Imagine that you are drawing a sharp razor vigorously across the ball of your thumb, or that you are sucking a lemon, and you will very likely have a sensation in your thumb or mouth. A man present at the disinterment of a coffin, by the order of the court, smelled such a putrid odour that he became violently ill. The action in the olfactory brain cells had caused the sensation of odour, for the coffin when opened was found empty. The influence of the imagination upon the body is due to the action of central brain cells.

The fact that the recall of past sensory experiences tends to modify the brain more effectually holds good, no matter whether we accept the theory that special brain cells are again set in action by the image, or that the same brain tract may be concerned in different reactions. In the latter case, reactions or vibrations of the same kind as the sensory stimulus, will accompany the image. The more often a thing reacts in the same way, the more definite are the modifications. If the same fingers have different movements for playing the harp and the piano, anything which leads to the repetition of either or both of those movements, tends to make them more definite and lasting.

It is possible to form of the same object as many as seven different images, more or less definite according to the special sense and to the peculiarity of the person. For instance, consider our sensory experiences with the cocoanut. When we lift it, there is (1) a sensation due to the muscular movement. We may afterward remember how heavy it felt. (2) As we pass our fingers over its shell, we obtain a characteristic tactile sensation, which we can reproduce. (3) We shall experience different temperature sensations in connection with the interior edible part, according to whether it has been kept on ice or in warm water. (4) When we tap on its shell there will be a sound, which we can recall. (5) There will be found a certain odour capable of reproduction. (6) When we eat the cocoanut, there will be a peculiar taste which can be remembered. (7) After looking at the cocoanut, we can reproduce its visual aspect. In addition to these seven sensations experienced in connection with the object, there are other memories associated with it, for instance, the memory of writing, of uttering, and of hearing the word "cocoanut."

All these different kinds of memory correspond to definite changes in brain cells, either in molecular arrangement or in dynamic reactions. When images corresponding to any sensory experience are recalled, there is the same kind of action as when the senses are externally stimulated, although this action is usually less intense. It becomes necessary, therefore, for us frequently to recall as many of these experiences as possible, if we wish the brain to acquire that permanent modification which is essential to lasting memory.

It is hard work for some to understand that there can be anything but sight images. When we see a rose, we can close our eyes and recall its visual appearance. What colour or shape has an odour image? we are asked. This question is just as sensible as to ask, What odour has the visual image of a rose? The senses of smell, of taste, of touch, and of hearing are as independent of sight as sight is of them. Each sense has its own memory images. The reason why this seems incomprehensible to many persons is because the majority have their senses very unevenly developed. In the case of most persons, sight is the sense which yields the most definite images. There are, however, many who can seem to hear a tune played by an instrument more vividly than they can recall the visual aspect of the instrument. To some, the most distinct attribute of the rose is its odour. Others can seem to feel soft things when they are no longer present to the sense of touch. When castor oil is mentioned to some people, the memories of taste are the most pronounced.

Some psychologists with a poor sense of smell have claimed that no definite odour images could be recalled, that only the muscular sensation in again sniffing in air from the imaginary object makes us think by the vividness of the accompanying muscular sensation that we are recalling the odour image. Against this view there is the positive testimony of persons who say that when a word like "pear," "rose," "turnip," or "codfish" is mentioned, the first image that comes to their mind is a definite odour image. Of course, the preliminary muscular sensation, due to inhaling the odour from the imaginary object, helps to make the image more definite and vivid.

Normal culture would see that the images of all the senses were equally distinct. No branch of training has been more neglected. The certain truth that the recall of images tends to modify the brain while it remains plastic has, as yet, received scant application in teaching. A proper exercise of the imaging power tends to cultivate all the sensory tracts symmetrically. In imaging, we can pass rapidly from the images of one sense to those of another. Thus, if we think of the odour of a rose, its visual aspect and tactile characteristics can then be brought to mind. The odour, taste, touch, and sight of a pineapple can be recalled. If we see a thing a dozen times as often as we are able to touch it, we can recall its tactile qualities more often than its visual, to make up for this deficiency. Introspective philosophy confirms the statement that the more often we think of a thing, the more firmly will it lodge in the memory. The physiological psychologist states the truth thus: Repeated actions of the same kind tend to make the corresponding brain modifications permanent.

Not very long since, Sir Francis Galton[1] called attention to the importance of training pupils to reproduce visual images of objects. He did not note the fact that sensory brain tracts are developed by such exercise, nor did he say much about the importance of such training in connection with direct sensory stimulation, but his work had sufficient merit for it to be called almost epoch-making. He writes as follows of the importance of the visualizing faculty:

"There is abundant evidence that the visualizing faculty admits of being developed by education. The testimony on which I would lay especial stress is derived from the published experiences of M. Lecoq de Boisbaudran, late director of the *École Nationale* in Paris. . . . He trained his pupils with extraordinary success, beginning with the simplest figures. . . . After three or four months' practice, their visual memory became greatly strengthened. They had no difficulty in summoning images at will, in holding them steady, and in drawing them. . . .

"I could mention instances within my own experience in which the visualizing faculty has become strengthened by practice; notably one of an eminent electrical engineer, who had the power of recalling form with unusual precision, but not colour. A few weeks after he had replied to my questions, he told me that my inquiries had induced him to practise his colour memory, and that he had done so with such success that he was become quite an adept at it, and that the

[1] *Inquiries into Human Faculty and its Development*, London, 1883.

newly acquired power was a source of much pleasure to him.

"A useful faculty, easily developed by practice, is that of retaining a retinal picture. A scene is flashed upon the eye; the memory of it persists, and details which escaped observation during the brief time when it was actually seen, may be analyzed and studied at leisure in the subsequent vision."

He then describes how persons differ in this visualizing power, as in the possession of other excellences. Of some he says: "They can call up the figure of a friend and make it sit on a chair or stand up at will; they can make it turn round and attitudinize in any way, as by mounting it on a bicycle or compelling it to perform gymnastic feats on a trapeze. They are able to build up elaborate geometric structures bit by bit in their mind's eye, and add, subtract, or alter at will and at leisure. The free action of a vivid visualizing faculty is of much importance in connection with the higher processes of generalized thought. . . .

"A visual image is the most perfect form of mental representation wherever the shape, position, and relations of objects in space are concerned. It is of importance in every handicraft and profession where design is required. The best workmen are those who visualize the whole of what they propose to do before they take a tool in their hands. . . . Strategists, artists of all denominations, physicists who contrive new experiments, and in short all who do not follow routine, have need of it. The pleasure its use can afford is immense. I have many correspondents who say that the delight of recalling beautiful scenery and great works of art is the highest that they know; they carry whole picture galleries in their minds. Our bookish and wordy education tends to repress this valuable gift of nature. A faculty that is of importance in all technical and artistic occupations, that gives accuracy to our perceptions and justness to our generalizations, is starved by lazy disuse, instead of being cultivated judiciously in such a way as will on the whole bring the best return. I believe that a serious study of the best method of developing and utilizing this faculty, without prejudice to the practice of abstract thought in symbols, is one of the many pressing desiderata in the yet unformed science of education."[1]

It is pleasing to find such high authority as Sir Francis Galton emphasizing something which should form a part of the training of every child. What he says of the recall of visual images is in large part applicable to the images of all the other senses. We are not aware that he or any one else has as yet specifically taught the importance of recalling images to render sensory brain modifications more definite and lasting. It is the province of this chapter to emphasize this necessity and to point out special ways in which to develop the power under consideration. The average mind needs not only to be told that a thing is necessary but also to be shown specific ways in which it may be secured.

There are probably no capacities in which persons differ more strongly than in the power to recall different sensory experiences. The product of any sense knowledge is a blur in the case of some people. Others are excellent in recalling visual images, while their auditory images are poor. We shall proceed on the assumption that if a person is deficient in any direction, there is all the more need for training in that direction. If a muscle is naturally weak, by all means let us try to strengthen it. True, it may not then become as strong as a giant's muscles, but it will improve.

[1] Galton's *Inquiries into Human Faculty and its Development*, pp. 105, 106, 107, 109, 113, 114.

Visual Images for Recall

In the absence of these objects, summon visual images of them. Note whether the image is as vivid as the object when before the eye. Are the colours as lively, the forms as distinct, the view as extended in the case of a landscape or of a number of objects?

Rose, daisy, clover, geranium, daffodil, crocus, marigold, violet, lilac, apple, peach, pear, hawthorn, and laurel blossoms, evening cloud, thunder cloud, full moon, quarter moon, the face of a friend, the colour of his hair and eyes, a red, green, and yellow apple, the bluish tinge on a cluster of grapes, a fish, lobster, cat, horse, lamb, cow, dog, rooster, duck, goose, a mountain, hill, landscape, stream with varying vegetation along its bank, the constellations of the stars, the varying surface of the ocean, a snow bank, snowflakes.

Can you summon distinct images of an oak and an elm leaf, place them side by side, and compare them? Can you bring the image of a remembered evening cloud and place the colour beside the cloud at which you are looking, and detect a difference in the shades? Can you go to a shop and match the colour of a ribbon left at home? Can you recall the images of two absent flowers, place these images side by side, and note the difference in the shape and colour? How many distinct shades of colour can you recall and project upon a sheet of white paper? Do salmon, lavender, magenta, and dove colour represent distinct shades, or are these terms principally meaningless sounds? After visiting an art gallery, can you recall vivid images of the principal paintings and take pleasure in looking at them? In reciting from memory, can you see the letters on an imaginary printed page?

Sir Francis Galton's[1] epoch-making questions on the visualizing power are in part as follows: "Before addressing yourself to any of the questions," he says, "think of some definite object — suppose it is your breakfast-table as you sat down to it this morning — and consider carefully the picture that rises before your mind's eye.

"1. *Illumination.* — Is the image dim or fairly clear? Is its brightness comparable to that of the actual scene?

"2. *Definition.* — Are all the objects pretty well defined at the same time, or is the place of sharpest definition at any one moment more contracted than it is in a real scene?

"3. *Colouring.* — Are the colours of the china, of the toast, bread, mustard, meat, parsley, or whatever may have been on the table, quite distinct and natural?

"4. *Extent of field of view.* — Call up the image of some panoramic view (the walls of your room might suffice); can you force yourself to see mentally a wider range of it than could be taken in by any single glance of the eyes? Can you mentally see more than three faces of a die, or more than one hemisphere of a globe at the same instant of time?

* * * * * * * * *

"7. *Persons.* — Can you recall with distinctness the features of all near relations and many other persons? Can you at will cause your mental image of any one or most of them to sit, stand, or turn slowly round? Can you deliberately seat the image of a well-known person in the chair and see it with enough distinctness to enable you to sketch it leisurely (supposing yourself able to draw)?

"8. *Scenery.* — Do you preserve the recollection of scenery with much precision of detail, and do you find pleasure in dwelling on it? Can you easily form mental pictures from

[1] *Inquiries into Human Faculty and its Development*, pp. 378, 379.

the descriptions of scenery that are so frequently met with in novels and books of travel ?"

Tactile, Temperature, and Muscular Images

When any one stoops to pick up a handful of snow or a piece of ice, he has three distinct sensations; one from touching the snow, one from the temperature of the snow, and one from the movements of the muscles employed in picking up the snow. When one eats a teaspoonful of ice-cream, there are also three sensations besides taste, — a tactile sensation when the cream comes in contact with the tongue, a sensation of temperature, and a muscular sensation in raising the spoon to the mouth and in moving the tongue.

Each of these sensations may be more or less accurately recalled. There must be quite a definite modification of the nervous system due to these different sensations. In many cases this modification remains largely sub-conscious, yet when we test a book in our hands and say that it weighs a pound and a half, it is clear that we are comparing this sensation with a remembered muscular sensation caused by that weight.

Let us endeavour to revive the sensations we originally had from

Touching snow
Touching files
Touching the edge of a knife
Touching feathers
Touching glue
Touching molasses
Touching cotton
Touching linen
Touching velvet
Touching wool
Touching hemp
Touching flax
Touching fur
Touching dough
Touching ice
Touching water
Touching putty
Touching pitch

Recall images of the varied muscular, tactile, and temperature sensations experienced while sleighing, skating, walking against a cold wind, ascending stairs, shaking hands, rowing a boat, playing a piano or any other musical instrument, dancing, house cleaning, moving furniture, slipping, or falling down, stroking a dog, cat, or the neck of a horse.

Taste Images for Recall

After repeatedly tasting the following named edibles, see how distinctly you can recall the

Taste of chicken	Taste of lemon	Taste of honey
Taste of duck	Taste of strawberry	Taste of sugar
Taste of quail	Taste of raspberry	Taste of molasses
Taste of turkey	Taste of pineapple	Taste of vinegar
Taste of shad	Taste of peach	Taste of castor oil
Taste of salmon	Taste of pear	Taste of turnip
Taste of herring	Taste of sour apple	Taste of celery
Taste of oyster	Taste of sweet apple	Taste of mustard
Taste of veal	Taste of custard	Taste of pepper
Taste of beef	Taste of chocolate	Taste of radishes
Taste of mutton	Taste of coffee	Taste of jelly
	Taste of maple syrup	

Can you place two taste images side by side, and be clearly aware of the difference between them? Compare, for instance, the remembered taste of chicken with turkey, of apple with peach, of cabbage with turnip, of mustard with horseradish.

Can you imagine the taste of a lemon or of a sour apple so vividly that you can note the resulting effects in the mouth, in perhaps a puckering sensation, or feeling as if the saliva was curdling?

It may be wise to call attention again to the fact that the more interest one feels in the taste and flavour of his food, the slower will he eat and the better will be his digestion. Many persons eat so fast and so many different things together, that no definite taste images are formed.

Odour Images for Recall

After carefully experimenting with each one, see how distinctly you can recall the

Odour of the rose	Odour of the sassafras
Odour of the tuberose	Odour of pennyroyal
Odour of the honeysuckle	Odour of fennel
Odour of the new-mown hay	Odour of turpentine
Odour of the lilac	Odour of tansy
Odour of the geranium leaf	Odour of the hyacinth
Odour of the magnolia	Odour of the carnation
Odour of the daisy	Odour of the blossoming orchard

After a little practice the majority of people, who have an average sensitiveness to odour, will be surprised at the rapid improvement in their power to recall different scents.

Auditory Images for Recall

Each day practise recalling some of the sounds mentioned below. For instance, recall the

Moaning of the pine	Buzzing of bees
Cackling of domestic fowl	Whistle of a locomotive
Songs of the birds; *e.g.* robin, canary, oriole, thrush	Bleating of sheep
	Barking of dogs

Sound of the flute, harp, violin, piano, organ, bagpipe, in playing some well-known air	Neighing of horses
Cry of the owl	Lowing of kine
Ringing of a bell	Whistle of quail
	Whir of a circular saw
	Voice of various friends

Can you recall the combined melody of the sounds of the forest, — *e.g.* rustling of leaves; song of birds; chirping of crickets; resonance of the cicada, katydid, or locust; tapping of the woodpecker's beak upon trees? Can you seem to hear a well-known air played from beginning to end as distinctly as if some instrument was actually playing it?

We shall now show how literature is constantly presenting us with objects wherewith to cultivate our imaging power. These objects will be found more interesting than those we have given in isolated lists, just as a wild flower is more charming in its own habitat than when plucked and placed in a vase. These examples will indicate to teachers and to students of literature how indefinite much of their knowledge is, and how more accurate cultivation of their senses may be necessary before they can form definite images. The writer has actually used these examples from literature, and others like them, to train the imaging power of his pupils. He would make them describe as accurately as possible the corresponding image in their own mind's eye. Where they failed from lack of sensory experience, he noticed how eager they were at the first opportunity to remedy the defect, and how much pleasure they had when the words evoked the sensory images necessary for the proper interpretation.

Rapid headway toward definite knowledge and modification of brain cells can be secured by forming images in terms of all the senses to interpret objects mentioned in literature.

Examples which show how the Study of Literature may serve to cultivate Imaging Power

Form definite images corresponding to the italicized words below. Whenever more than one sense can be used in the interpretation, employ as many as possible. If a bird is mentioned, recall the song as well as the visual aspect; if a flower, the odour as well as the colour and shape.

"And the *woodbine spices* are wafted abroad
And the *musk* of the *roses* blown,
For a *breeze* of morning moves,
And the *planet* of Love is on high,
Beginning to faint in the light that she loves
On a bed of *daffodil sky*."

TENNYSON.

In this passage, there should be formed a distinct image of the visual appearance and odour of the woodbine and of the rose. Tactile and temperature images of a morning breeze, visual images of the planet Venus, and of a sky the colour of the daffodil must also be formed. The writer can testify from his personal experience that pupils, in order to have their images of the colour of the sky exact, brought into the classroom the first daffodils that appeared. The students would probably not have done this, had they not been required to image all objects referring to any of the senses.

"The soft complaining *flute*."

The visual aspect and sound of the flute should be distinctly recalled.

"And let your silver *chime*
Move in melodious time."

The sound of the ringing of a chime of bells should be represented here, and, less important, the appearance of the bells.

> "Call for the *robin* redbreast and the *wren*
> Since o'er shady *groves* they hover."

Image the robin and the wren distinctly enough to be drawn, then describe the variation in their colour, proceeding back from the head. Recall their characteristic song. Image distinctly a grove.

> "Fear no more the *lightning* flash
> Nor the all-dreaded *thunder* stone."

The above italicized words ought to suggest vivid visual and auditory images.

> "When *icicles* hang by the wall."

Here the temperature and visual senses are appealed to.

> "It was a *lover* and his lass
> That o'er the green *cornfield* did pass."

Describe the dress, complexion, colour of hair and eyes of the lover and lass you seem to see in the cornfield.

> "There will we sit upon the *rocks*
> And see the *shepherds feed* their *flocks*,
> By shallow *rivers* to whose falls
> Melodious *birds sing* madrigals."

> "The *fields* breathe *sweet*, the *daisies* kiss our feet."

> "A *bee-hive's hum* shall soothe my ear."

> "A *violet* by a *mossy* stone."

> ". . . a forsaken bird's *nest* fill'd with *snow*."

In the above lines, as many images as possible should be formed of the objects referred to in italics. For instance, the odour and visual image of the violet, the touch as well as the sight of the mossy stone, the temperature image of the snow, should be recalled.

> "The *swan* on still Saint Mary's Lake
> *Float double*, *swan* and *shadow*."

> "Now all the *tree-tops* lay asleep,
> Like *green waves* on the sea."

> "The *frozen wind* crept on above,
> The *freezing stream* below."

The last two lines appeal more strongly to the temperature than to the visual sense.

In order to get to sleep, Wordsworth used to practise recalling images of

> "A *flock of sheep* that leisurely pass by
> One after one; the *sound* of *rain* and *bees*
> *Murmuring*; the *fall* of *rivers*, *winds* and *seas*,
> *Smooth fields*, *white sheets of water* and *pure sky*."

> ". . . *floating water lilies*, broad and bright."

The person who can image the following objects distinctly may consider himself fitted to read the poetry of nature:

> ". . . thou shalt hear
> Distant *harvest-carols* clear;
> *Rustle* of the *reapèd corn*;
> Sweet *birds antheming* the morn:
> And in the same moment — hark!
> 'Tis the early April *lark*,
> Or the *rooks* with busy *caw*,

Foraging for *sticks* and *straw*.
Thou shalt at one glance behold
The *daisy* and the *marigold*;
White-plumed *lilies*, and the first
Hedge-grown *primrose* that hath burst;
Shaded *hyacinth*, alway
Sapphire queen of the mid-May;
And every *leaf*, and every *flower*,
Pearlèd with the self-same *shower*,
Thou shalt see the *field mouse* peep
Meagre, from its *cellèd* sleep;
And the *snake* all winter-thin
Cast on *sunny bank* its *skin*;
Freckled nest eggs thou shalt see,
Hatching in the *hawthorn tree*
When the *hen-bird's wing* doth rest
Quiet on her *mossy nest*;
Then the hurry and alarm
When the *bee-hive* casts its *swarm*;
Acorns ripe down *pattering*
While the autumn *breezes sing*."

". . . *islands* that together lie
As quietly as *spots of sky*
Among the *evening clouds*."

"We lay beneath a spreading *oak*,
  Beside a *mossy seat*;
And from the *turf* a *fountain* broke
  And *gurgled* at our feet."

"Where the *bee sucks*, there suck I:
In a *cowslip's bell* I lie;
There I couch when *owls* do *cry*;
On the *bat's back* I do fly."

"The *oriole* should *build* and tell
His *love-tale* close beside my *cell;*
The idle *butterfly*
Should rest him there, and there be *heard*
The housewife *bee* and *humming-bird*."

After the various sensory images can be formed of separate objects, an effort should be made to construct a picture in which several elements form their due proportion. Some of Tennyson's poetry furnishes excellent material for this larger view. The writer has practised pupils to pass before their mind's eye and to describe orally a complete picture corresponding to such passages as these:

"One seem'd all dark and red — a tract of sand,
And some one pacing there alone,
Who paced for ever in a glimmering land,
Lit with a low large moon."

When different pupils described the picture suggested to them by these lines, there was of course a difference because of varied experiences. One pupil said: "I see a broad sandy shore, sloping toward the south. The tide is low, and there is only a slight moaning of the waves. I face the south, and at my right are the dark red clouds of twilight; at my left, the rising moon. I see in the gloom a figure wrapped in a black cloak, slowly pacing the sands. His head is bowed, and his arms are folded." Another pupil placed the scene in the desert, away from the ocean, and still another thought of a desolate moor.

"One show'd an iron coast and angry waves.
You seem'd to hear them climb and fall
And roar rock-thwarted under bellowing caves
Beneath the windy wall."

A pupil described this as an eastern coast with rocks rising a hundred feet from the water's edge. The sea had worn out a cavern under the rock, and the echoing sound of the waves can be heard as they dash in and are turned back. The waves are a blackish gray colour, tipped with foam as white as snow. Clouds are chasing each other across the sky. One pupil described the promontory of Marblehead, Massachusetts, and another, a rocky headland on the coast of Maine.

> "And one, a full-fed river winding slow
> By herds upon an endless plain,
> The ragged rims of thunder brooding low,
> With shadow-streaks of rain."

This was described as "a river meandering toward the south. The pastures on either side are luxuriant with clover, buttercups, and daisies, rising to the cattle's knees. The kine have large bluish, dreamy eyes. Some of the cattle are yellowish brown or tawny with white throats and breasts. Others are pied; that is, bluish black and white. Some are eating; others chewing the cud. There is a silvery tinkle of bells. About twenty-five degrees above the western horizon, there is a thunder cloud, blackish gray in colour. There are trailing mist-like streaks depending from this cloud to the earth."

> "A still salt pool, lock'd in with bars of sand,
> Left on the shore; that hears all night
> The plunging seas draw backward from the land
> Their moon-led waters white."

A picture like this is a pure luxury only to those who can form definite visual and auditory images to correspond to such a scene. When such journey inland, they are never without the sight and sound of the sea.

Wherever we turn in literature, we find objects to develop the imaging power. We open Browning, and see an image of a mountain in spring:

> "Now again to be softened with verdure, again hold the nest
> Of the dove, tempt the goat and its young to the green on his crest."

We pick up Izaak Walton and read:

> "But turn out of the way a little, good scholar, towards yonder high honeysuckle hedge; there we'll sit and sing, whilst this shower falls so gently upon the teeming earth, and gives a yet sweeter smell to the lovely flowers that adorn these verdant meadows."

Perhaps the right kind of literature can in no way be made more serviceable than in developing the power of making images to correspond to the natural objects mentioned. The faces of pupils glow with pleasure when they have definite images wherewith to interpret what is read; but a listless look soon spreads over the countenances of those who cannot summon the fitting images. We must repeat, as we close this chapter, that the recall of images tends toward brain modification in the same manner as the original sensations.

CHAPTER X

How Shakspere's Senses were Trained

"In Nature's infinite book of secrecy
A little can I read."

Antony and Cleopatra.

"The bounteous huswife, nature, on each bush
Lays her full mess before you."

Timon of Athens.

Not only in the case of art, architecture, and music, but also in all branches of human development, intellectual and moral, the study of models is very important. We ought to study the lives of the greatest men of all time, as examples and incentives; the lives of commonplace individuals and of failures, as warnings. A great man, even a genius, is a product, an exemplification of the laws of cause and effect. A genius does not introduce lawlessness into life; he rather shows the most perfect workings of law.

Every one ought to know how Shakspere's senses were trained; for in his sensory experience is to be found the foundation of all those imperishable structures given to humanity by his heaven-climbing genius. Two things are true of Shakspere, — his senses had magnificent training; the stimuli of nature also had in him a wonderful central nervous system to develop. We shall not reach his heights, but if we have the proper training, we shall ascend far higher than we could without it. If John Weakling can never make a Samson, that is no reason why John should not take proper gymnastic exercise and develop his latent powers to the utmost. At their best they may be poor; at their worst, they may keep him through life the slave of underlings. After going through sensory training similar to Shakspere's, any boy would be better fitted to cope with the world.

Since so little is known of Shakspere's life, it may be asked how anything definite can be said of the way in which his senses were trained. The question is not so difficult as it might at first seem. There are persons who can take a finished shoe, piece of cloth, watch, or musical instrument, and tell the steps by which it was made. Shakspere has left a vast quantity of finished products. His mind worked according to psychological laws in constructing his dramas. What one sees himself is apt to impress him more vividly than what another tells him. The most vivid images come to our minds first; they sway most strongly the current of our association of ideas. We are more apt to talk and write about our own sensory experiences than what we have learned at second-hand. The psychologist can, therefore, trace many of Shakspere's expressions to their sensory source. For instance, when he says:

> ". . . daffodils
> That come before the swallow dares, and take
> The winds of March with beauty,"

the psychologist is sure that no such loving appreciation of the daffodils was voiced, unless his eyes had fallen on them in their own habitat on some March day, when he looked for the swallow and found her not.

Again, when he sings:

> "When daisies pied and violets blue
> And lady-smocks all silver-white
> And cuckoo-buds of yellow hue
> Do paint the meadows with delight,"

we feel that he must have seen with appreciative eyes the daisies, violets, lady-smocks, and cuckoo-buds. When we find those same flowers in the meadows around Stratford, we are certain that we have found some of the things that developed his senses.

When he says of one of his characters:

> "Alas! poor hurt fowl, now will he creep into sedges,"

we feel that in his walks or boyish hunts he had seen a wounded fowl try to hide itself in the sedges and feel its misery alone.

When we find that many sensory objects which he mentions in his plays could have been seen by romping youth every year in incomparable Warwickshire, we may feel sure that they formed part of Shakspere's sensory experiences. Bayne correctly says: "We know, for example, that Shakspere was born and lived for twenty years at Stratford-upon-Avon; and we can say therefore with certainty that all the physical and moral influences of that picturesque and richly-storied Midland district melted as years went by into the full current of his ardent blood, became indeed the vital element, the very breath of life his expanding spirit breathed. We know a good deal about his home, his parents, and his domestic surroundings; and these powerful factors in the development of any mind gifted with insight and sensibility must have acted with redoubled force on a nature so richly and harmoniously endowed as that of the Stratford poet. It would be difficult indeed to overestimate the combined effects of these vital elements on his capacious and retentive mind, a mind in which the receptive and creative powers were so equally poised and of such unrivalled strength."[1]

[1] *Shakspere Studies.*

Antiquarians have traced out the source of the majority of Shakspere's plots. In the case of the remainder, the critics confidently expect some day to find the source, and their experience during the last fifty years has fully justified this expectation. When there are passages in his plays that appeal to direct sensory experience, it is equally sensible to endeavour to ascertain how and where he gained that experience. If we find its possible source in his environment in Stratford-on-Avon and the adjacent country, we ought to be as well satisfied as the critic who discovers in an old chronicler the suggestion for a play. It is surprising that so much more attention should have been given to the musty volumes in which Shakspere found suggestions from books than to the objects of nature and of humanity that were his real educators.

Before proceeding further, it will be wise to ascertain what Shakspere learned at school, and whether the Elizabethan age made the present mistake of confining children too much to books. We can then form a better idea of how much he owed to bookish training and how much to nature studies.

Bayne[1] gives us a list of the books in use in the Free Grammar School of St. Bees in Cumberland, in 1583. They are as follows:

The A B C in English.
The Catechism in English, set forth by public authority.
The Psalter, Book of Common Prayer, and the New Testament in English.
The Queen's Grammar, with the Accidence.
The Small Catechism in Latin, publicly authorized.
Confabulationes Pueriles.

[1] "What Shakspere Learnt at School," Littell's *Living Age*, Vol. 145, p. 742.

Prose
- Æsoppi Fabulae.
- M. T. Ciceronis
  - Epistolæ Minores Selectæ.
  - Officiorum.
  - De Amicitia.
  - De Senectute.
  - Tusculanarum Questionum.
  - Orations, or any other of his works.
- Salustius.
- Justinius.
- Commentarii Cæsaris.
- Q. Curtius.

Verse
- Distica Catonis.
- Terentius.
- Virgilius.
- Horatius.
- Ovidii Metamorphoses.
- Ovid: de Tristibus.
- B. Mantuanus.
- Palingenius.
- Buchanani Scripta.
- Sedulius.
- Prudentius.

Of these, Bayne says: "This list, having been prepared on authority within five or six years after Shakspere left school, may be accepted as representing fairly enough the books and authors usually read in the country grammar schools.

"From these various sources, contemporary and quasi-contemporary, we may form a trustworthy general estimate of Shakspere's course of instruction during his school-days. At that time . . . boys usually went to the grammar school about six or at latest seven years of age, and entered at once upon the accidence. In his first year, therefore, Shakspere would be occupied with the accidence and grammar. In his second year, with the elements of grammar, he would read some manual of short phrases and familiar dialogues, and these committed to memory would be colloquially employed in the work of the school; in his third year, if not before, he would take up Cato's *Maxims*, and Æsop's *Fables;* in his fourth, while continuing the *Fables*, he would read the Eclogues of Mantuanus, parts of Ovid, some of Cicero's *Epistles*, and probably one of his shorter treatises; in his fifth year would continue the reading of Ovid's *Metamorphoses*, with parts of Virgil and Terence; and in the sixth, Horace, Plautus, and probably part of Juvenal, and Persius, with some of Cicero's *Orations* and Seneca's *Tragedies*."

It is to be doubted whether any modern school could show a much worse list than this. Excepting the New Testament, which was probably not employed as a regular text-book, there are only two works on the list that are suited to children. Æsop's *Fables* would inspire a love of animal life and hence tend to sharpen the senses for observing its forms. Ovid's *Metamorphoses* would appeal to the imagination. These statements should, however, be qualified. These two would be good juvenile books, only in case they were properly studied. If pupils conned them as mere word gymnastics or parsing exercises, the conning did little good. No one was ever educated by studying words. Words are symbols that represent either definite sensory experiences, or ideas and feelings which have for their foundation such experiences.

The writer once knew a teacher who was very fond of developing fluency of expression in his pupils. This was a most laudable object, and had they been taught aright, their knowledge of words would have progressed no faster than that of the sensations corresponding to them. He, however, required them to memorize a list of words indicative of different shades of colour:

Lurid, pearly, ebon, tawny, dapple, maroon, amber, saffron, cerulean, sapphire, pied, etc.

A class of thirty-five, that remembered these words as well as the declension of *mensa*, was asked to indicate some natural object of a *lurid* colour. Not a single pupil was able to do this. Many otherwise good teachers are to-day careless about making their pupils interpret such terms in the light of definite sensory experiences.

In several of his plays Shakspere has given us a good idea of the way in which children were taught in his day. As he is the best authority on that subject, we quote from the *Merry Wives of Windsor:*

"*Mrs. Page.* How now, Sir Hugh! no school to-day?

Sir Hugh Evans. No; Master Slender is let the boys leave to play.

Mistress Quickly. Blessing of his heart!

Mrs. Page. Sir Hugh, my husband says my son profits nothing in the world at his book. I pray you ask him some questions in his accidence.

* * * * * * * * * * *

Evans. William, how many numbers is in nouns?

William. Two.

Quickly. Truly, I thought there had been one number more, because they say 'Od's nouns.'

Evans. Peace your tattlings! What is 'fair,' William?

William. Pulcher.

Quickly. Polecats! there are fairer things than polecats, sure.

Evans. You are a very simplicity 'oman: I pray you, peace. What is 'lapis,' William?

William. A stone.

Evans. And what is 'a stone,' William?

William. A pebble.

Evans. No, it is 'lapis': I pray you, remember in your prain.

William. Lapis. .

Evans. That is a good William. What is he, William, that does lend articles?

William. Articles are borrowed of the pronoun and be thus declined, Singulariter, nominativo, hic, hæc, hoc.

Evans. Nominativo, hig, hag, hog; pray you mark: genetivo, hujus. Well, what is your accusative case?

William. Accusativo, hinc.

Evans. I pray you have your remembrance, child; accusativo, hung, hag, hog."

We may smile at William, but we cannot help pitying him when we think that the majority of his book-learning was kin to this. In *Love's Labour's Lost,* we are shown adults making pedantic use of the wordy knowledge acquired in the schoolroom:

"*Holofernes.* The deer was, as you know, sanguis, in blood, ripe as the pomewater, who now hangeth like a jewel in the ear of cælo, the sky, the welkin, the heaven; and anon falleth like a crab on the face of terrâ, the soil, the land, the earth.

Nathaniel. Truly, Master Holofernes, the epithets are sweetly varied, like a scholar at the least: but, sir, I assure ye, it was a buck of the first head.

Holofernes. Sir Nathaniel, haud credo.

Dull. 'Twas not a haud credo; 'twas a pricket.

Holofernes. Most barbarous intimation: yet a kind of insinuation, as it were, in via, in way, of explication; facere, as it were, replication, or, rather, ostentare, to show, as it were, his inclination, after his undressed, unpolished, uneducated, unpruned, untrained, or rather, unlettered, or, ratherest, unconfirmed fashion, to insert again my haud credo for a deer.

Dull. I said the deer was not a haud credo; 'twas a pricket.

Holofernes. Twice — sod simplicity, bis coctus. O thou monster Ignorance, how deformed dost thou look!

Nathaniel. Sir, he hath never fed of the dainties that are bred in a book; he hath not eat paper, as it were; he hath not drunk ink.

* * * * * * * * * * *

Moth. (*Aside to Costard.*) They have been at a great feast of languages and stolen the scraps.

Costard. O, they have lived long on the alms-basket of words. I marvel thy master hath not eaten thee for a word; for thou art not so long by the head as honorificabilitudinitatibus."

There are still some persons who think that Shakspere did not have a sufficient amount of book-learning to write his plays. We can safely maintain that if he had had much more of the current book-learning, he could never have written them. As we shall see later, he was rescued just in time from this "learning." It may be all very well to increase one's vocabulary by suddenly memorizing twenty new words or synonymous forms of expression, but if not a single new idea has been added to the mental store, the gain is doubtful. In reply to the question of Polonius, "What do you read, my lord?" Shakspere makes his masterly inactive character reply,

"Words, words, words."

The master in his inmost soul must have felt the special aptness of this reply.

In *Love's Labour's Lost* the pedantic Holofernes quotes from Mantuanus, an oft-read author. A school-teacher, a short time after Shakspere, selects this very passage to show how that Latin author was studied:

"For afternoon lessons on Wednesdayes, let them make use of Mantuanus, which is a poet, both for style and matter, very familiar and gratefull to children, and therefore read in most schooles. They may read over some of the Eclogues that are less offensive than the rest, takeing six lines at a lesson, which they should first commit to memory, as they are able. Secondly, construe, thirdly, parse. Then help them to pick out the phrases and sentences, which they may commit to a paper book; and afterwards resolve the matter of their lessons into an English period or two, which they may turn into elegant and proper Latine, observing the placing of words according to prose."

The fact that Mantuanus was extremely poor poetry mattered little. As in the case of many modern text-books, he furnished plenty of words, and they were sufficient.

On account of his father's pecuniary difficulties, Shakspere probably left school shortly after passing his fourteenth birthday. This was extremely fortunate. Had he not left school at that age, we might to-day be without the greatest dramas of all time. At any rate, those who favour going to school for the chief purpose of studying books, must acknowledge that earth's greatest writer did stop school at about the age of fourteen and yet surpassed even those who spent half their lives at school.

We have investigated the books used in Shakspere's time and the manner of studying them sufficiently to be sure that he did not receive much sensory training at school. How was it, then, that Shakspere became the best-educated man of any age? The answer is that he had magnificent sensory training and he made the proper motor responses thereto. Before we consider in detail how he received this training, we may quote a general statement from a man familiar with every foot of Shakspere's haunts: "His mind became a vast reservoir of facts and fancies, but the facts were not acquired nor were the fancies stimulated within the dingy walls of King

Edward's Grammar School. The Stratford meadows, gay and bright with flowers from early springtime till late autumn; the Wier Brake, where the earliest primroses come, and 'where the nightingales sing the night long'; the noble forest of Arden which stretched away through northwestern Warwickshire, with its hunting scenes and woodland idyls; the Whitsuntide celebrations, the May-pole dances, the sheep-shearing festivals, and the mystery plays; and on the banks of the Avon, less than a dozen miles away, the noble castles of Warwick and Kenilworth, about which as a centre the history of England revolved for centuries — these are some of the places where Shakspere acquired his education. Let one roam about this beautiful country for a year or two and steep himself in the spirit of its history and traditions, and he will cease to wonder where the great poet gained his chief knowledge of life and nature, or whether he was really the author of the writings attributed to him. The spirit of the Midland Counties breathes through his pages, and much of his work is only a poetically idealized picture of what his eyes actually beheld."[1]

Shakspere was also extremely fortunate in having parents who could neither read nor write. Both made their mark when it was necessary for them to sign documents. On October 15, 1579, John and Mary Shakspere, the parents of the poet, sold their interest in a piece of land at Snitterfield. The document is signed, "The marke + of John Shackspere. The marke + of Marye Shacksper." Halliwell-Phillipps says, "Both parents of the poet were absolutely illiterate." If we take "illiterate" in its etymological sense, *i.e.* without knowledge of written or printed letters, the statement is probably correct. It is, however, probable that John and Mary Shak-

[1] Williams' *Homes and Haunts of Shakspere*, p. 13.

spere were better educated than the average well-to-do inhabitants of our best cities at the present day. This may sound strange to those who think that all knowledge necessarily comes from books. We can therefore be safe in assuming that the greater part of whatever information his parents had, came from the exercise of their own senses in the experience of life. Their senses would be the keener because they could not rely on books. It is an excellent thing for a child to associate with those who are acute observers, for their example reacts on him and makes him see more. Herein lies the reason why Shakspere was fortunate in having intelligent parents who were not bookish. By force of example they taught him to rely largely on his senses for information.

It is probably true that Mary Shakspere was as perfect a specimen of mother as the world ever produced, as great in motherhood as her son grew to be in the drama. Among seven daughters, Mary Arden was her father's favourite. She came of an illustrious Warwickshire family "of gentle birth and good breeding." She was probably the sympathetic teacher who guided her son's observing eyes. Her mental and moral traits became a part of him. We can safely conclude that some of his magnificent pictures of womanhood owed much to her. His early conception of womanhood, unconsciously gained from her, probably influenced him in drawing the character of Perdita. When Mary Arden was a girl, she almost certainly performed the common domestic duties on her father's farm, and so she might, like Perdita, have been called

"The queen of curds and cream."

When he shows us Perdita speaking of the flowers as if she loved them like her own children, he may have been thinking of walks with his mother in the meadows around Stratford, when, for instance, she may have pointed out to his young eyes

> "The marigold, that goes to bed wi' the sun
> And with him rises weeping . . .
> . . . violets dim,
> But sweeter than the lids of Juno's eyes."

If a picture like this serves to incite any mother to cultivate her powers of observation so that she may be a true companion to her children in the most important period of their sensory development, she may have the satisfaction of knowing that she will thereby encourage them to walk in the paths which Shakspere trod.

A consideration of the environment in which Shakspere was placed becomes very important in connection with his sensory development. Many a plant, animal, and human being have not developed fully because of lack of fitting environment.

Nowhere in England could Shakspere have found better environment for sensory training than in the fields and forests that circled Stratford-on-Avon. There is a story of two Englishmen laying a wager in regard to the finest walk in England. After the wagers had been deposited with the stake-holder, the one named the walk from Stratford-on-Avon to Coventry, and the other, from Coventry to Stratford-on-Avon.

Some of the objects on which Shakspere's youthful eyes could have rested, are thus enumerated by Bayne: "Below the church, on the margin of the river, were the mill, the mill-bridge, and the weir, half-hidden by gray willows, green alders, and tall beds of rustling sedge. And beyond the church, the college, and the line of streets, . . . the suburbs stretched away into gardens, orchards, meadows, and cultivated fields, divided by rustic lanes with mossy banks, flowering hedgerows.

and luminous vistas of bewildering beauty. These cross and country roads were dotted at intervals with cottage homesteads, isolated farms, and the small groups of both which constituted the villages and hamlets included within the wide sweep of old Stratford parish. . . . The town was thus girdled in the spring by daisied meadows and blossoming orchards, and enriched during the later months by the orange and gold of harvest fields and autumn foliage, mingled with the coral and purple clusters of elder, hawthorn, and mountain ash, and, around the farms and cottages, with the glow of ripening fruit for the winter's store."

A man who knows the Warwickshire Avon well, writes thus of it: "Perhaps the most interesting part of the Avon is the twenty miles of its course stretching from Kenilworth to Bidford — Kenilworth being some twelve miles above Stratford, and Bidford about eight miles below. It is this part of the river with which Shakspere was most familiar. Many months have been spent by the writer along its banks since that summer morning when, for the first time, he leaned over the parapets of Clopton Bridge and saw the white swans floating on its silvery surface. It has been a companion in all moods and seasons — in spring, when the tender green of the meadows is flecked with the white snow of the daisies; in early summer, when its rippling surface dances in the sunshine, when the hawthorn hedges send out their exquisite perfume, and the watercourses are marked by great bunches of golden king-cups; in the long midsummer evenings, when mystic shadows play about the thickets —

> "'Where nightingales in Arden sit and sing
> Amongst the dainty, dew-impearled flowers;'

and again in winter when the magic of the hoar-frost converts every weed into a fairy wand and robes the meanest object with beauty." [1]

Shakspere gives an excellent description of Warwickshire in those lines in which Lear assigns to his eldest daughter Goneril her portion:

> "Of all these bounds, — even from this line to this,
> With shadowy forests and with champains rich'd,
> With pleasant rivers and wide-skirted meads, —
> We make thee lady."

Change of environment is an important factor in the cultivation of the senses. Where the stimuli from natural objects are few, or where they are almost constantly the same, the nervous system becomes somewhat less responsive to them. The perfumer is less keenly sensitive to odours in his own shop. The factory hand soon ceases to notice the din of the machinery, but any strange noise immediately arrests his attention. There were within easy walking distance of Stratford two farms where John and Mary Shakspere would have been welcome with their handsome boy. Each of these farms would have seemed almost like fairyland to him, furnishing, as they would, a striking contrast to the village. There are some of us who can remember the marvels which a short stay in the country afforded us. We were absorbed in what seemed wonders to our childish eyes: freshly laid eggs, the broods of chickens, ducklets mysteriously swimming on a deep pond where we dared not venture, the lambs with which we essayed to play, the geese which advanced in a threatening manner toward us, the calves, colts, and little pigs, at first almost snow-white, the wild berries, the orchard with its birds'-nests and fruits. One of these farms, where the brown-eyed William would have been

[1] Williams' *Homes and Haunts of Shakspere*, p. 66.

welcome, was at Snitterfield, three and one-half miles northeast of Stratford. At this village with the unpoetical name, the future poet's paternal grandfather and Uncle Henry lived. Three miles to the northwest of Stratford was Wilmcote, where his mother's family, the Ardens, lived on a fine old farm.

Williams thus speaks of a walk from Stratford to Snitterfield: "Just behind the Welcombe Hills which rise to the northwest of Stratford-on-Avon, dozes in its quiet little valley the old-world village of Snitterfield. The name is not poetical, but there dwelt the forefathers of one who, through his poetry, created the world anew. A leisurely walk of an hour and a half from Stratford one sunny afternoon in springtime, delayed somewhat by many wayside rambles to gather the old English wild flowers which in rich profusion 'carpeted all the way with joy,' at last led us down a hillside street, quite overhung with widespreading branches of noble oaks and elms, and so we came into the hamlet where once lived the ancestors of William Shakspere. It is a beautiful village of perhaps thirty or forty cottages, a few of which are old, but the most of them comparatively modern, scattered over the hillside that bounds the eastern side of the valley. A softly flowing stream, crossed by fords and rustic foot-bridges, winds about through the meadows and cottages at the foot of the hill." [1]

It must be remembered that a slight change of environment means much more to a boy than to adults; for the world and its mysteries must be explored by him bit by bit. Many of us can recall the time when anything three miles away might have seemed in the heart of fairyland. Speaking of Shakspere's boyhood, Bayne says: "There were during these years at least three of the forest farms where the poet's parents would be always welcome, and where the boy must have spent many a

[1] Williams' *Homes and Haunts of Shakspere*, p. 2.

happy day amidst the freedom and delights of outdoor country life. At Snitterfield his grandfather would be proud enough of the curly-headed youngster with the fine hazel eyes, and his uncle Henry would be charmed at the boy's interest in all he saw and heard as he trotted with him through the byres and barns, the poultry-yard and steading, or, from a safe nook on the bushy margin of the pool, enjoyed the fun and excitement of sheep-washing, or later on watched the mysteries of the shearing and saw the heavy fleece fall from the sides of the palpitating victim before the sure and rapid furrowing of the shears. He would no doubt also be present at the shearing feast, and see the queen of the festival receive her rustic guests and distribute amongst them her floral gifts. At Wilmcote in the solid oak-timbered dwelling of the Asbies, with its well-stocked garden and orchard, the boy would be received with cordial hospitality, as well as with the attention and respect due to his parents as the proprietors, and to himself as the heir of the maternal estate. At Shottery the welcome of the Shaksperes would not be less cordial or friendly, as there is evidence to show that as early as 1566 the families were known to each other, John Shakspere having in that year rendered Richard Hathaway an important personal service."

A careful reading of Shakspere's plays will disclose many of the objects which served to sharpen his powers of observation. Whenever these objects were such as to be met with frequently in his Warwickshire environment, it is safe to assume that he knew them at first hand. It is true that he mentions things to be found only in a foreign land, but he was able to grasp these more clearly because his sense-knowledge was so wide. He could from a mere description assimilate these unseen things to what he had previously seen. Even he could interpret new things only in terms of his past experience.

It will be interesting for us to select from his works some of the natural objects which he noticed. If we accustom our children, our pupils, or ourselves to observe these same objects, we may have the consciousness that we are following in Shakspere's steps, trying to educate ourselves and those around us after his fashion. Patterson[1] says: "I was thus led to examine the plays of Shakspere with respect to the notices of natural objects which they contain, and I soon found that these notices were much more numerous than I had expected. I transcribed the passages containing them, under the several heads which naturalists have adopted in their classifications, and found, to my surprise, that they occupied one hundred closely written pages of letter paper. Of these, twenty-two pages related to the mammalia; sixteen to birds; nine to reptiles and fishes; two to shells and minerals; nine to insects; thirteen to trees, flowers, and fruits; and twenty-nine to those ever-varying features which mark the progress of the seasons, or depict some of the countless phenomena of nature."

It should be noticed that Shakspere never lugs in a reference to any natural object unless it is called for to illustrate a point or strengthen a passage. He never tries to show us how much he knows on any subject. Some modern poets have started out with the direct object of cataloguing nature and they have introduced more natural objects than he did. But he probably knew vast numbers that he never mentioned, because the special turn of the play never called for them.

We shall have space to quote only a few of the passages in which such objects are mentioned. We quote the passages because the objects thus seem more interesting in the setting which he gave them.

[1] *Insects mentioned in Shakspere's Plays*, p. 11.

First, let us take insects, which were not too small to escape his observant eye.

> "She never told her love;
> But let concealment, like a worm i' the bud,
> Feed on her damask cheek."
>
> *Twelfth Night*, II., 1.

> "Then for the third part of a minute, hence;
> Some to kill cankers in the musk-rose buds."
>
> *Midsummer Night's Dream*, II., 2.

> "Newts and blind-worms, do no wrong,
> Come not near our fairy que- -.
>
> * * * * * * *
>
> Weaving spiders, come not here;
> Hence, you long-legg'd spinners, hence!
> Beetles black, approach not near;
> Worm nor snail, do no offence."
>
> *Midsummer Night's Dream*, II., 2.

"*Prince*. Shall we be merry?
Poins. As merry as crickets, my lad."

Henry IV., Part I., Act II., 4.

We can imagine with what exquisite pleasure Shakspere penned this line, because he was then recalling his boyhood pleasures:

> "Where the bee sucks, there suck I."

"Monsieur Cobweb, good Monsieur, get your weapons in your hand, and kill me a red hipp'd humble-bee on the top of a thistle; and, good Monsieur, bring me the honey-bag."

Midsummer Night's Dream, IV., 1.

> "The honey-bags steal from the humble-bees,
> And for night-tapers crop their waxen thighs
> And light them at the fiery glow-worm's eyes,

To have my love to bed and to arise;
And pluck the wings from painted butterflies
To fan the moonbeams from his sleeping eyes."
Midsummer Night's Dream, III., 1.

In the reply of Bottom to Cobweb, Shakspere shows that he had learned the surgical uses of the product of the spider's loom:

"*Bottom.* I shall desire you of more acquaintance, good Master Cobweb: if I cut my finger, I shall make bold with you."

". . . Thou shalt be pinch'd
As thick as honeycomb, each pinch more stinging
Than bees that made 'em."
Tempest, I., 2.

In this picture of a colony of bees Shakspere shows that he had carefully watched them:

". . . for so work the honey-bees,
Creatures that, by a rule in nature, teach
The act of order to a peopled kingdom.
They have a king and officers of sorts:
Where some, like magistrates, correct at home;
Others, like merchants, venture trade abroad;
Others, like soldiers, armed in their stings,
Make boot upon the summer's velvet buds;
Which pillaged they with merry march bring home
To the tent-royal of their emperor;
Who, busied in his majesty, surveys
The singing masons building roofs of gold,
The civil citizens kneading up the honey;
The poor mechanic porters crowding in
Their heavy burdens at his narrow gate."
Henry V., I., 2.

He thus constructs Queen Mab's carriage:

> "Her wagon-spokes made of long spinners' legs;
> The cover, of the wings of grasshoppers;
> The traces, of the smallest spider's web;
> The collars, of the moonshine's watery beams:
> Her whip, of cricket's bone: the lash, of film:
> Her waggoner, a small gray-coated gnat,
> Not half so big as a round little worm
> Prick'd from the lazy finger of a maid:
> Her chariot is an empty hazel-nut,
> Made by the joiner squirrel, or old grub."
>
> *Romeo and Juliet*, I., 4.

In Macbeth's speech before the murder of Duncan, Shakspere shows that he had observed the accompaniments of the approach of darkness.

> ". . . ere the bat hath flown
> His cloister'd flight; ere to black Hecate's summons
> The shard-borne beetle, with his drowsy hums,
> Hath rung night's yawning peal, there shall be done
> A deed of dreadful note."

No doubt Shakspere recalled juvenile memories, when he had Petruchio ask:

> "Who knows not where a wasp doth wear his sting?"

In the beautiful meadows about Stratford, his own motor and sensory experiences might have prompted him to write:

> ". . . a very pretty boy. O' my troth, I looked upon him o' Wednesday half an hour together: has such a confirm'd countenance. I saw him run after a gilded butterfly; and when he caught it, he let it go again: and after it again; and over and over he comes, and up again; catched it again."
>
> *Coriolanus*, I., 3.

He had also noticed "wholesome herbs swarming with caterpillars." He distinguished accurately between the gilded fly, the blow fly, the gad fly, and the gnat. He had doubtless risen before light for some youthful excursion and first noticed the approach of twilight because the glow-worm began to shine less distinctly. In *Titus Andronicus*, III., 2, Shakspere shows us that his careful observation of insect life had taught him a lesson of kindness:

"*Marcus.* Alas, my lord, I have but kill'd a fly.
Titus. But how if that fly had a father and mother?
How would he hang his slender gilded wings,
And buzz lamenting doings in the air!
Poor harmless fly!
That, with his pretty buzzing melody,
Came here to make us merry! and thou hast kill'd him."

We have ample proof that flowers, both wild and domestic, furnished rich material for the training of Shakspere's senses. In proof of this statement, we have to read only the *Winter's Tale* and the *Midsummer Night's Dream.* We shall find these pages redolent with the breath of flowers. In fact, no finer poetry about the flowers can be found than the pages of the *Winter's Tale* contain. There are also others of his plays which are like spring meadows dotted with wild flowers. In this class we may mention the *Tempest*, *Hamlet*, *Cymbeline*, *Romeo and Juliet*, and *Lear*.

We have already quoted in preceding pages some of the finest Shaksperian passages about flowers, and so it is not necessary to give a large number here. We can follow Shakspere in his boyhood as he romped around the meadows and streams of Warwickshire, his brown eyes sparkling with delight while he looked on scenes which he recalled later in such lines as these :

"I know a bank where the wild thyme blows,
Where oxlips and the nodding violet grows,
Quite over-canopi'd with luscious woodbine,
With sweet musk-roses and with eglantine."

We find him regretting some spring which had evidently impressed him because the frost came late and killed the flowers.

". . . hoary-headed frosts
Fall in the fresh lap of the crimson rose,
And on old Hiem's thin and icy crown
An odorous chaplet of sweet summer buds
Is, as in mockery set."

We find him singing in lines that seem to overflow with joy :

"Merrily, merrily shall I live now
Under the blossom that hangs on the bough."

From such a passage as this, written probably in London, with the Stratford fields uppermost in memory, one might infer where Shakspere loved to tumble, when a boy :

". . . Give me swift transportation to those fields
Where I may wallow in the lily beds."

And again :

"In the woods where often you and I
Upon faint primrose beds were wont to lie."

When the troubles of manhood came, we find him hopefully speculating that

". . . the time will bring on summer,
When briars shall have leaves as well as thorns,
And be as sweet as sharp."

> "Their lips were four red roses on one stalk,
> Which in their summer beauty kissed each other."

> "So sweet a kiss the golden sun gives not
> To those fresh morning drops upon the rose."

The violet was a great favourite with Shakspere. We have a beautiful wish about Ophelia:

> "And from her fair and unpolluted flesh
> May violets spring."

> ". . . The south wind
> That breathes upon a bank of violets,
> Stealing and giving odour."

As we follow Shakspere, we walk through meadows and by the side of streams. Noticing the direction of his sympathetic glance, our eyes rest on pale primroses, weeping marigolds, daffodils that come before the swallow, bold oxlips, cowslips adorned with pearls by fairy hands, the pied daisy, the violet that has taken its gentle colour from the heavens and its odour from a sweeter source than the breath of the goddess of Love, the azured harebell, the honeysuckle, fragrant rosemary, rue, and lavender, the pansy to move the stream of thought. As we look at these carefully with sympathetic eyes, we may know that we are cultivating our senses on the same material that nature gave to her greatest child for that purpose.

A point well worth noticing is that his flowers, with but very few exceptions, are those of the spring. This fact shows that contrast and a change in environment quicken the senses. The spring flowers are much more noticeable because they present such a striking contrast to the barrenness of winter. The senses finally become surfeited with the profusion of flowers and vegetation, and the attention is less strongly attracted in their direction. The fact that Shakspere lived in a village helped, however, to make a tramp into the country seem more novel than if he had spent all his time on a farm. Ruskin ascribed his own great love for the beauties of nature largely to his having been born in London. When he saw the country as a boy, it seemed to him an Eden in contrast with smoky London. We must remember that contrast is one of the most potent causes of attention. A stage whisper following a loud tone, a sour taste succeeding a sweet one, the charm of the country to a city child, the buds and blossoms of spring when they first clothe the barren branches, claim a special hold on the attention. This truth is emphasized by one of Shakspere's lines relating to a spring flower:

> "Showed like April daisy on the grass."

When we come to compare Shakspere's flowers with those of Milton, we see how much more accurate was the dramatist's knowledge. A part of this superiority was of course due to Shakspere's greater genius, but a part must also be ascribed to the fact that his senses were trained earlier than those of Milton. The Puritan poet was born in London, and he did not go to live amid the fine scenery at Horton until after he had graduated from college. At this time his senses had in great part lost their early plasticity. A botanist, commenting on Milton's mistakes, says: "The violet is not a 'glowing' flower; wild thyme does not mingle with the 'gadding vine'; nor does the jessamine 'rear high its flourished head.'"

Botanists have found but one error in Shakspere's description of flowers. This occurs in *Cymbeline*, in the passage:

> "A mole cinque-spotted, like the crimson drops
> I' the bottom of a cowslip."

The spots in the bottom of a cowslip can scarcely be called crimson, although they might appear so to a painter of the impressionistic school, and Shakspere may have looked at them when he felt impressionistic. This one exception, however, may serve to emphasize more deeply the truth that he was a man of *accurate*, as well as of wide, observation.

A forest has generally a mysterious fascination for most boys. In the case of Shakspere, we may say that no natural objects impressed his senses more strongly than the life of the forest. Luckily, his environment afforded plenty of noble forests within easy distance of Stratford. Bayne says: "In the second half of the sixteenth century, however, the Arden district still retained enough of its primitive character to fill the poet's imagination with the exhilarating breadth and sweetness of woodland haunts, the beauty, variety, and freedom of sylvan life, and thus to impart to the scenery of *As You Like It* the vivid freshness and reality of a living experience. In this delightful comedy the details of forest life are touched with so light, but at the same time, so sure a hand, as to prove the writer's familiarity with the whole art of venery, his thorough knowledge of that 'highest franchise of noble and princely pleasure' which the royal demesnes of wood and park afforded. In referring to the marches or wide margins on the outskirts of the forest, legally known as purlieus, Shakspere, indeed, displays a minute technical accuracy which would seem to indicate that in his early rambles about the forest and talks with its keepers and woodmen, he had picked up the legal incidents of sylvan economy, as well as enjoyed the freedom and charm of forest life. . . .

"Not only in *As You Like It* but in *Love's Labour's Lost*, in *Midsummer Night's Dream*, in the *Merry Wives of Windsor*, and indeed throughout his dramatic works, Shakspere displays the most intimate knowledge of the aspects and incidents of forest life; and it is certain that in the first instance this knowledge must have been gained from his early familiarity with the Arden district. This, as we have seen, stretched to the north of Stratford in all its amplitude and variety of hill and dale, leafy covert and sunny glade, giant oaks and tangled thickets — the woodland stillness being broken at intervals not only by the noise of brawling brooks below and of feathered outcries and flutterings overhead, but by dappled herds sweeping across the open lawns or twinkling in the shadowy bracken, as well as by scattered groups of timid conies feeding, at matins and vespers, on the tender shoots and sweet herbage of the forest side. The deer-stealing tradition is sufficient evidence of the popular belief in the poet's love of daring exploits in the regions of vert and venison, and of his devotion, although in a somewhat irregular way perhaps, to the attractive woodcraft of the park, the warren, and the chase."

In *As You Like It*, Shakspere has mentioned a few of the text-books from which he learned most:

> "And this our life exempt from public haunt,
> Finds tongues in trees, books in the running brooks,
> Sermons in stones and good in everything.
> I would not change it."

The rustics in the *Midsummer Night's Dream* rehearsed their play in a spot perhaps similar to the one selected by the youthful Shakspere and the other boys of Stratford for their imitation of plays given by the strolling actors:

> ". . . here's a marvellous convenient place for our rehearsal. This green plot shall be our stage, this hawthorn-brake our tiring-house."

Passages like the following show his minute perception of forest minutiæ:

"Under an oak whose antique root peeps out
Upon the brook that brawls along this wood."

". . . an oak, whose boughs were moss'd with age
And high top bald with dry antiquity."

"*Oliver.* Where in the purlieus of this forest stands
A sheep-cote fenced about with olive trees?
Celia. West of this place, down in the neighbour bottom.
The rank of osiers by the murmuring stream,
Left on your right hand brings you to the place."

". . . Kate, like the hazel twig,
Is straight and slender; and as brown in hue
As hazel nuts, and sweeter than the kernels."

". . . In such a night as this,
When the sweet wind did gently kiss the trees,
And they did make no noise."

By his references to them, Shakspere shows us that he had noted the myrtle, the willow growing "ascaunt the brook," the yew, aspen, hawthorn, box tree, birch, ash, elm, elder, sycamore, as well as the forms of forest life that ran its course under their boughs.

It was in the forest that Shakspere became acquainted with "the joiner squirrel," the subtle fox, the timorous hare, the "dormouse of little valour," and the deer. Harting says of him: "The knowledge which he displays of our wild animals, as the fox, the badger, the weasel, and the wild-cat, could only have been acquired by one accustomed to much observation by flood and field." Shakspere would naturally have become a hunter quite young, and as such he would have found it necessary to notice carefully the habits of the denizens of the forest and the field. His descriptions of the hounds in the fourth act of the *Midsummer Night's Dream*, and of the wounded deer in the second act of *As You Like It*, are such as could scarcely have been written by any one who had not carefully observed those animals.

Boys are generally much attracted by birds. Children under the age of ten often say that they would like to become birds. In the first place, a moving object naturally attracts a child, and then the child can scarcely help coveting the freedom of movement, the power to hop at ease among the branches, or to fly over ponds and marshes. It is fortunate if the environment of children contains many different kinds of birds. The intermingling of forest, stream, and cleared land in Warwickshire made it a favourite haunt for birds.

Shakspere's plays are especially rich in mention of birds. We can see that he observed them from many different points of view. From certain lines, we may infer that he was familiar with the nests of the kite, the wren, the martin, the raven, and the jay. Birds' nests and eggs are usually objects of admiring wonder to a boy, and it is probable that Shakspere would have felt curiosity enough to search for them. A line in the *Winter's Tale*,

> "When the kite builds, look to lesser linen,"

shows that he was familiar with some of the characteristics of that bird in building its nest. The shadow of a hawk or eagle floating over the branches or the ground will instantly still the songsters and put the barn-yard fowl to flight. He shows in these lines that this fact had not escaped him :

> "The eagle suffers little birds to sing,
> And is not careful what they mean thereby,
> Knowing that with the shadow of his wing
> He can at pleasure stint their melody."

The birds of prey and their various habits are mentioned again and again. The vulture, osprey, kite, buzzard, crow, and various kinds of hawks come in for their full share of attention. The sport of hawking had evidently served to quicken his powers of observation. He uses, in connection with this sport, terms that only an expert in the art could have understood.

Expressions like the following show that Shakspere was up betimes, and that he had an eye for feathered life:

> ". . . The busy day
> Wak'd by the lark, hath rous'd the ribald crows."

He had evidently noticed the ugly eyes of the lark and the beautiful ones of the toad, for he makes Juliet say:

> "Some say the lark and loathed toad change eyes."

In the *Midsummer Night's Dream* our attention is called to several birds in Bottom's song. It would be excellent training for the powers of observation to describe the shape, plumage, song, and habits of each of these accurately:

> "The ousel cock [blackbird] so black of hue,
> With orange-tawny bill,
> The throstle with his note so true,
> The wren with little quill,
> The finch, the sparrow, and the lark,
> The plain-song cuckoo gray."

After he had caught certain birds, he noticed the behaviour of the little captives:

> "She fetches her breath so short as a new-ta'en sparrow."

He shows that he had compared the jay and the lark, when he asks the question :

> "What, is the jay more precious than the lark
> Because his feathers are more beautiful ?"

The early superiority in movement of the young of animals over those of the human species had attracted his attention. He tells us that

> "The lapwing runs away with the shell on his head."

We can imagine the boyish wonder of Shakspere when he saw

> "Strange fowl light upon neighbouring ponds,"

and how he would watch them, notice what they ate, and try many devices for securing them.

Domestic fowl also served as material for the cultivation of his senses. He has written about the cock, peacock, goose, duck, turkey, swan, pigeon. While sitting in London writing the *Tempest*, he could recall vivid youthful memories of the merry matin call of the cock :

> "Hark ! hark ! I hear
> The strain of strutting chanticleer
> Cry, Cockadiddle-dowe."

In the *Two Gentlemen of Verona*, Shakspere has one of his characters speak of geese and of his dog in a way that would indicate real experience along the lines suggested :

> "I have stood in the pillory for geese that he hath killed, otherwise he had suffered for 't."

From the following expression, one might imagine that Shakspere had tried to capture wild geese:

"Nay, if our wits run the wild-goose chase, I am done."

It would be interesting to know the number of boys who had actually seen swans, and who could be positive about the colour of their legs. Shakspere shows that he remembered such things:

"For all the water in the ocean
Can never turn a swan's black legs to white,
Although she lave them hourly in the flood."

In connection with birds, Shakspere nowhere shows more exact and sympathetic powers of observation than in speaking of the martin or "martlet":

"This guest of summer,
The temple-haunting martlet, does approve
By his loved mansionry, that the heaven's breath
Smells wooingly here: no jutty, frieze,
Buttress, nor coign of vantage, but this bird
Hath made his pendent bed and procreant cradle:
Where they most breed and haunt, I have observed,
The air is delicate."

We may mention these as some of the birds that served as material for the cultivation of Shakspere's senses:

The cuckoo, lark, bunting, chough, owl, crow, dove, eagle, vulture, raven, pheasant, jay, swallow, kite, thrush, robin, woodcock, daw, wren, quail, sparrow, cygnet, buzzard, goose, nightingale, snipe, duck, lapwing, finch, blackbird, martin, pigeon, rook, hawk, hen, starling, cock, mallard, and osprey.

It will afford excellent sense training to imitate Shakspere in learning all we can about as many of these birds as our environment will enable us to see.

He had noticed the fruits, both wild and domestic. A boy's keen appetite would be sure to sharpen his senses in that direction. A gentleman recently said that the keenest delight he ever knew was when hunting for luscious wild strawberries, yet cool with the morning dew, on a fragrant day in June in New England. We find a line in Shakspere which shows us where his youthful brown eyes had rested:

> "The strawberry grows underneath the nettle."

In his pages we catch glimpses of dewberries, mulberries, purple wild grapes, blackberries, cherries, and other fruits that make our mouths water.

When the youthful poet roamed around the forest farms of his relatives at Snitterfield or Wilmcote, the common weeds did not escape him. To a child whose senses are well-trained, as well as to a great man, no natural object is common or mean. In a passage where King Lear's madness is graphically portrayed, he is represented as

> "Crown'd with rank fumiter and furrow-weeds,
> With burdocks, hemlock, nettles, cuckoo-flowers,
> Darnel, and all the idle weeds that grow
> In our sustaining corn."

Shakspere has vividly described the land of the thriftless farmer, such as he might perhaps have seen in the vicinity of his paternal grandfather's place:

> ". . . her fallow leas
> The darnel, hemlock, and rank fumitory
> Doth root upon, while that the coulter rusts
> That should deracinate such savagery;
> The even mead that erst brought sweetly forth
> The freckled cowslip, burnet, and green clover,

Wanting the scythe, all uncorrected, rank,
Conceives by idleness and nothing teems
But hateful docks, rough thistles, kecksies, burs."

The phenomena of inanimate nature, always more beautiful and varied in the country, left their impress upon his youthful sensory tracts. Rising early on a dubious morning, he noticed

". . . what envious streaks
Do lace the severing clouds in yonder east:
Night's candles are burnt out, and jocund day
Stands tiptoe on the misty mountain tops."

He also speaks of

". . . a red morn, that ever yet betoken'd
Wreck to the seaman, tempest to the field,
Sorrow to shepherds, woe unto the birds,
Gusts and foul flaw to herdmen and to herds."

In like vein we have

"How bloodily the sun begins to peer
Above yon busky hill! the day looks pale
At his distemperature."

"Full many a glorious morning have I seen
Flatter the mountain tops with sovereign eye,
Kissing with golden face the meadows green,
Gilding pale streams with heavenly alchemy."

"But look, the morn in russet mantle clad,
Walks o'er the dew of yon high eastward hill."

The phenomena of sunset also caught his eye:

"Thy sun sets weeping in the lowly west,
Witnessing storms to come."

And, again,

"The weary sun hath made a golden set."

Even the winds brought him material wherewith to cultivate his senses:

> "The southern wind
> Doth play the trumpet to his purposes,
> And by his hollow whistling in the leaves
> Foretells a tempest and a blustering day."

An over-enthusiastic lover is said to be

> "Like foggy south, puffing with wind and rain."

Although Shakspere received fine sense training from the field, the forest, and the sky, his genius must have made him instinctively know that this was incomplete. There is to-day the tendency to train the senses almost exclusively on natural objects. The flower, leaf, bird, insect, and sky ought always to be included in the list of text-books for sensory training, but Shakspere's example ought to emphasize to us the fact that these are not all. Human beings of almost every occupation were observed with keen interest by Shakspere in his boyhood. Had he not supplemented the training due to natural objects by watching his own kind as carefully as he noted the "strange fowl" alighting on "neighbouring ponds," we should not to-day have his dramas. The rascal Autolycus and the alewife Mistress Quickly demanded as keen observation as the violets or the temple-haunting martlet. In no respect does Shakspere tower above the rest of humanity more than in his careful observation of all classes of men in every mood.

For good opportunities to study different types of human beings, a village is in some respects distinctly superior to either the city or the country. A person may live in a city without knowing anything of those dwelling on the next street, or, indeed, much of those who live next door. In a village, one may know considerable about almost every one else. A chance to watch people at their different occupations is of great importance for children. The village blacksmith shop or mill has been no mean factor in cultivating the senses of many a child. In a village, people live on more of an equality. The merchant, the blacksmith, the squire, and the miller may all sit near each other at church, or stroll down street together, discussing some village event. Their children grow up in the same way, and, in consequence, they have a chance for a wider and more intimate acquaintanceship with human beings. An aristocratic city child rarely ventures into a blacksmith shop. He will therefore lack that broad human sympathy which is necessary to quicken the powers of observation.

When Shakspere was born, Stratford-on-Avon had the free and easy life of a country town. All classes of human beings, from the nobleman to the weaver, from the justice to the cobbler, could be seen, and in most cases, freely spoken to on the streets or at the public houses of the village. A critic has well said : "To Shakspere all aspects of life, even the humblest, had points of contact with his own. He could talk simply and naturally without a touch of patronage or condescension to a hodman on his ladder, a costermonger at his stall, the tailor on his board, the cobbler in his combe, the hen-wife in her poultry yard, the ploughman in his furrow, or the base mechanicals at the wayside country inn."

If, after leaving school, he helped attend to his father's store, the future poet would have had a rare chance for observing different classes of human beings. His plays show that he did not neglect the chance ; for we may there find drawn with a sure hand the peddler, cobbler, smith, musician, strolling player, soldier, apothecary, alewife, porter, gardener, tinker, clown, shepherd, grave-digger, sexton, merchant, doctor, justice, par-son, tailor, carpenter, and many others. Such lines as these show how carefully he had watched them :

> "I saw a smith stand with his hammer, thus,
> The whilst his iron did on the anvil cool,
> With open mouth swallowing a tailor's news;
> Who, with his shears and measure in his hand,
> Standing on slippers, which his nimble haste
> Had falsely thrust upon contrary feet."

The itinerant peddler and his wares are well-described in the *Winter's Tale*, as are also the customs at a sheep-shearing festival, a holiday to which a boy was certain to look forward with great expectancy. In *The Taming of the Shrew*, we get an excellent picture of the life and habits of a tinker :

> "Am not I Christopher Sly, old Sly's son of Burton-heath, by birth a peddler, by education a card maker, by transmutation a bear-herd, and now by present profession a tinker. Ask Marian Hacket, the fat alewife of Wincot, if she know me not: if she say I am not fourteen pence on the score for sheer ale, score me up for the lyingest knave in Christendom."

The sense training which Shakspere received from watching his own kind broadened his sympathies and made him feel that all men were brothers. This enabled him practically to realize the poetical truth that "utter knowledge is but utter love." He is never found sneering at the lowest menial. Few of his portraits are more worthy of admiration than that of the old servant Adam in *As You Like It.*

Well-to-do city children of the present time are frequently taught to avoid workmen and their children. The young aristocrat thus acquires a contempt for handicraftsmen and their various arts, which appeal so strongly to the senses. His powers of observation will never be broadly trained, for no one can become a good observer in a direction where he has no sympathy. In *A Midsummer Night's Dream*, Shakspere has in the person of King Theseus taught all a lesson in this direction. A bellows-mender, tinker, tailor, joiner, carpenter, and weaver had in the rudest fashion rehearsed a play which they wished to present at the royal nuptials:

> "*Theseus*. What are they that do play it?
> *Philostrate*. Hard-handed men that work in Athens here,
> Which never labour'd in their minds till now,
> And now have toil'd their unbreathed memories
> With this same play against your nuptial.
> *Theseus*. And we will hear it.
> *Philostrate*. No, my noble lord,
> It is not for you; I have heard it over,
> And it is nothing, nothing in the world.
> * * * * * * * *
> *Theseus*. I will hear that play;
> For never anything can be amiss,
> When simpleness and duty tender it."

And so Shakspere has taught us that broad sympathy must be cultivated in order to make any one a good observer.

From a study of Shakspere's environment and his plays, we have learned what stimuli played upon his sensory brain tracts, and what ones made the deepest impression. We can do no better than to train the senses of the young with these very stimuli, or with so many of them as the environment will furnish. It is true that such training will not make Shaksperes, but it will vastly improve those who receive it. A study of mathematics will not make Newtons out of all pupils, but it will render them more capable in the battle of life. Such a training of the senses as Shakspere received will go far toward bringing in the golden age of education.

CHAPTER XI

Motor Training

Sensations exist for the specific purpose of inciting us to action, either immediate or remote. If they fail to initiate the proper action, their failure is absolute. Even in so simple a case as sitting down to dinner, if the sensations due to seeing and smelling the viands on our plates do not lead to motor action, we should finally starve. When our barbaric progenitors saw edible wild fruit, they plucked and ate it. A question is asked us, and the sensation of sound acts upon the motor speech region, leading to a reply to the question. We touch an acid or a hot substance, and withdraw our hands to escape serious harm. When newsboys see a handful of pennies thrown among them, the sensation results in immediate scrambling for the coins. Life in an analogous way exposes good things to our sight. It is not enough for us to see them, we must act in a way best suited to get them. The man of action bears away the prizes of life. It must not be forgotten that human actions are possible only because nerve cells are capable of undergoing certain modifications, that the product of a sensation affects a motor centre, and action results in terms of the original capacity and subsequent habituation of that centre.

When a sensation first pours into an infant's brain, certain cells are set in action. With this action comes development of connective nerve fibres. Motor connections are thus developed and rendered stable. We have already seen that there is an increase in the number of tangential nerve fibres up to the age of thirty-three. (See p. 56.) We cannot watch a growing brain with a microscope, and we are, therefore, in ignorance of the precise way in which these associative fibres develop. We do, however, know that such fibres are merely outgrowths of cells. It is highly probable that the development takes place in the following manner: Exercise causes more blood laden with nutritive elements to flow to the cells. This increased nutrition demands an outlet, which can be furnished in several ways; first, by growth in the cell proper; second, by the growth of nerve fibres, and third, by the excitation and propagation of motor action along these fibres after they are developed. When a tree is planted in rich soil, a part of the nutriment goes to develop the branches, but an equally important part is expended in growing new roots and rootlets. If the tree is exercised by severe winds, the roots strike deeper into the soil. We shall probably do no violence to brain development by holding that an analogous process takes place there. As the cells are exercised and draw more nutritive blood to them, not only may the cellular modification become more complex, without striking increase in their size, but connective fibres may also grow out from them like roots from a tree.

Brain exercise of all kinds is accompanied with motor elements. Physics teaches that no force is ever lost; its direction may be changed; it may be resolved into half a dozen different paths instead of flowing on in a straight line. When a sensation pours into a nerve cell, the energy from this sensorial stream is not swallowed up and lost. A part of this energy is absorbed in modifying the cell, and a part tends to flow out in motor action. A sensation, which gave rise to no motor element, was never experienced. This element may be very small in connection with some sensations, but it exists. A mistake is often made in thinking that motor action is developed only when an intense sensation is felt, as when some one treads on our toes. When a baby sees a bright object and reaches for it, or when a man sees a lamp-post and avoids it, we have examples of a part of the sensory energy, communicated to the brain cells, taking a motor direction and influencing the muscles.

If the proper associative nerve fibres in the brain are not developed by fitting nurture and training, there must be both motor and sensory deficiency. When we see a flying bird, raise our guns, and shoot it; when we see various piano keys and dextrously touch them; when the soldier hears a command from his drill master, and replies with the fitting muscular movements, — it is plain that there must be connection between the various sensory and motor nerve cells. If such was not the case, the appropriate movement would not be forthcoming. Strictly speaking, one can study neither sensory nor motor action by itself, for every sensation has its motor accompaniment.

The truth that sensation tends to pass into movement shows us that the foundation for motor development lies in sensory training. Where post-mortem examination has shown a deficiency in any sensory tract due to the early loss of any sense, there has also been a deficiency in the number of fibres leading from this tract. We can therefore give as a practical rule: See that the sensory cells have the proper stimuli pouring into them, then immediately act on the motor prompting, if the suggested action is not an unwise one. Some of us have actually experimented with young children in two different kinds of environment; first, where the sensory promptings were poor, and, secondly, where they were rich and varied. For instance, a child in the back yard of a city house will act for the most part only in so far as prompted by internal muscular sensations. Place the same child in a meadow. A buttercup strikes his eye and he runs to pluck it. Perhaps he next sees a daisy and gathers that. A butterfly flits by and he chases it. When tired, he lies down, and the fatigued cells are built up stronger than before as a result of the exercise and increased absorption of nutriment. The point should be noted that the environment in the back yard and in the meadow differs in the fact that the one furnishes scarcely any external sensations to prompt movement, while the other is rich in such suggestions.

Many a city child has not developed into a man of pronounced action, because his early environment presented but few sensory promptings. Perhaps he was educated under his mother's eye and allowed to play but little with other children. When in the latter part of his teens, he finally goes into a large school or a college, he has no disposition to engage in games that call for much action or decision. Of course a disposition to action, or the opposite, is partially a matter of heredity, but we must not forget that many develop their natural powers very imperfectly. On precisely the same tract of land, one farmer will often raise twice as much as another.

That must always remain an inferior brain where the fitting motor reactions do not follow sensations, original or revived in the form of memory images. In every walk of life we see dreamers who are content with the revived shadows of sensations, men who have so far as possible divorced ideas from the suggested actions.

Before we can proceed further, we must understand what is meant by an idea or image. The definition of an object of memory as the "shadow of a sensation" is not strictly correct, but the figure is forcible enough to impress on us vividly a not uncommon characteristic of such objects. In preceding chapters we have striven to show that training should be such as to eliminate as far as possible this indefinite, shadowy characteristic of recalled sense objects. It is, however, sometimes wise to define things as we most often find them, and not as we fancy they ought to be.

We can gain the clearest idea of an object of memory from a study of the physiological processes involved. We glance at a rose, and the stimulus from it sets brain cells in action. We close our eyes and image this rose. There is then less intense action in these same cells. It is possible that these cells might be roused to such intense action in the absence of the rose, that we might be sure we saw it. This is precisely what happens in an illusion. Some internal cause then stimulates the brain to as great activity as if sensations from actual objects were pouring into the cells. The line of demarcation by which we judge between a remembered and a present object is thus sometimes obliterated, and we can then, of course, not distinguish between them. There are few of us who have not at some time or other had similar experiences. Most of us can recall how absolutely sure we were that we had recently seen a certain thing in a certain place, when all we had experienced was an extremely vivid recall of the object in that place. Men of irreproachable morals have testified on oath to seeing something at a certain place at a given time, because brain cells have been set in intense action in the process of remembering. Most of us have been sure that we have done a certain thing, when we have not, put something in its place, when we actually left it lying out of its proper position, merely because we threw so much energy into the *idea* of performing the action, that we can actually seem to recall having done it.[1]

[1] See Halleck's *Psychology and Psychic Culture*, pp. 108, 109.

When an image is formed, a part of the activity in the correlated brain cells tends to flow out in motor action. We have already seen that the natural tendency of a sensation is to cause motor action. Since an image is a revived sensation, usually less intense than the original, we can the better understand why images should have motor accompaniments and also why these should be less strong than those resulting from a direct sensation. Imagine eating a peach or some luscious fruit, and you will notice, if the image is vivid, that the glands of the mouth are affected. If we had an instrument sufficiently fine, we should probably also find incipient muscular movement in the muscles of the tongue and jaws. If we form an image of a lofty mountain, there will be movement in the delicate muscles controlling the eye. If we image the odour of a honeysuckle, there will be movement in the muscles controlling inhalation. Sensations from this muscular movement will be reflected to the brain and will make the odour image more vivid. No image can be formed without causing a more or less intense motor outflow. What we have before said concerning the cultivation of sensory tracts by forming images of sense objects applies also to the cultivation of motor tracts, since a sensory stimulus means a motor outflow. The fact that such movements initiated by this outflow are often promptly checked, does not disprove the existence of a sensory cause. We often prevent the usual effect which results from a cause by introducing a counter cause. In the same way, the will often inhibits the movement which would naturally follow a sensation. I see a pear on a tree which is not mine. The motor tendency is to pluck and eat. I restrain this tendency by an act of will, which develops a counter idea.

Recent psychology has done some of its best work in demonstrating the existence of a motor element in every act of memory as well as in every sensation.

Thus, Külpe says: "Movements are everywhere important. It is perhaps not too much to say that a voluntary recollection never takes place without their assistance. When we think of intense cold, our body is thrown into tremulous movement, as in shivering; when we imagine an extent of space, our eyes move as they would in surveying it; when we recall a rhythm, we mark its rise and fall with hand or foot." [1]

We may further say that all states of consciousness contain a motor element. From the moment the first sensation is experienced until approaching dissolution snuffs out the last spark of consciousness, there is a motor element constantly accompanying it. If it was not for this, consciousness would be unprogressive, even stagnant. There could be no association of ideas. One changeless idea would remain before the mind for all life. Because of this motor element, one idea leads to another, and the mind, instead of being like a stagnant pond, resembles a running brook.

It may be asked why we speak of motor ideas any more than of wet water, if every sensation and every memorial image have a motor element. The answer is that ideas differ in the proportion in which this motor factor stands to other elements. The consciousness of different people differs in regard to the motor element as much as two brooks differ in the rapidity of their current. It may take some persons a quarter of an hour to grasp what another sees in a momentary glance. The extent of the mental life cannot be measured by years. If Methusaleh was a sluggish man, Shakspere really lived ten thousand years longer, and Napoleon outlived any easy-going patriarch.

[1] *Outlines of Psychology*, p. 187.

A motor idea is one in which the motor element is specially prominent. The image of an object at rest has less of this element than the image of an object in motion. If we form a definite image of such an object, we shall note the difference at once, and we shall very likely experience a different cerebral feeling. Literary criticism which does not call attention to motor images does not amount to much. We shall best understand them by noting and endeavouring to construct images of some moving natural objects in order to interpret the masters in literature. Shakspere says:

"... those lily hands
Tremble, like aspen leaves, upon the lute."

"And Cytherea, all in sedges hid,
Which seem to move and wanton with her breath."

"And winking Mary-buds begin
To ope their golden eyes."

"Hop as light as bird from briar."

"Rough winds do shake the darling buds of May."

In the above lines, there are hands, aspen leaves, sedges, flowers, birds, and buds, not at rest, but moving. In fact, motion is their most prominent quality. The same is true of the images which the following lines suggest.

"The bluebird, shifting his light load of song
From post to post along the cheerless fence."

"The thin-winged swallow skating on the air."

"She seem'd as happy as a wave
That dances on the sea."

"The wild white bees of winter
Swarm through the darkened air."

"But pleasures are like poppies spread,
You seize the flower, its bloom is shed!
Or like the snowfall in the river,
A moment white — then melts forever;
Or like the borealis race
That flit ere you can point their place;
Or like the rainbow's lovely form,
Evanishing amid the storm."

"Where the heifers browse — where geese
Nip their food with short jerks."

In these lines, we have moving bluebirds, swallows, waves, snowflakes, petals of flowers, aurora borealis, rainbows, heifers, and geese. This motor element, whether of the snow melting in the river or of the goose nipping the grass, is what gives individuality and meaning to the object. The image of a field of waving wheat is much more interesting than of the same field when still.

Motion alone produces anything, hence we can see the importance of motor ideas. Unfortunately the world is infested with a class of people, the activity in whose sensory tracts is not paralleled by action in the motor cells. A sensation may evaporate from the brain without causing the proper action, just as rich land may exist and be further fertilized by showers and yet produce no crops of value. The motor element involves effort and this is not always pleasant.

A glance around us is nearly certain to discover some persons of marked deficiency in the world of action. They may like to learn and to continue absorbing knowledge, but they never make any worthy use of it. A visit to the reading-rooms of any library will enable us to find chronic sponge-like absorbers of whatever is written. Their very faces come to have a dreamy relaxed expression. These persons generally fancy that they are "going to do" something soon, but the motor paralysis becomes more and more complete. Sometimes boys are allowed to bury themselves in book after book, until action becomes extremely irksome to them. They love to absorb ideas and to direct all their motor energy into dreaming or castle-building. In the case of the majority of people, motor action needs to be cultivated, and to be directed to definite ends. It is not enough for one to form an idea of becoming a great man; he must do things to make himself great.

Suggestion has much power in arousing the central nervous system to action. One of the best practical rules that we can formulate for developing the motor tendency in the central nervous system is this: Bring suggestion of the right kind to bear on growing youth.

So few people have a really clear idea of what suggestion is, that we must explain its bearings. When a train of sensations, ideas, or thought — in short, when any mental train — is suddenly interrupted by any object or idea, with strong motor qualities, this new object or idea is specially fitted to develop action in its direction. This definition, like all others, requires concrete illustrations to make it plain. An infant's eyes will follow a ball rolling across the floor, although they will speedily lose the ball when at rest. A child playing in a meadow will chase a butterfly flitting by. In these cases, sense objects in motion broke in upon the child's mental train, and suggested movement of eye or of the entire body in their direction. A part of this movement was of course reflex, but we must remember that reflex movement in nerve cells lies at the basis of every higher act of will. A sensory stimulus pours into a nerve cell, is reflected outward along a motor nerve, and movement results. The highest acts of will merely have deliberation, choice, and inhibition added to these foundation reflexes.

Imitation is the result of suggestion. A child on a visit watched the facial contortions of a person afflicted with St. Vitus' dance, and soon began from sympathetic imitation to acquire the same movements. When this child returned home, the affection spread to the other children. These nervous twitchings would probably soon have become habitual, had not the children been carefully separated from each other and exposed to nothing that suggested such movements. Persons have become confirmed stammerers from early association with one who stuttered. The motor response to impulses to speak soon became habitually uncertain. In fact, the stammering made a permanent change in the reactions in the motor cells. The writer knows a child who contracted from an older person the permanent habit of squinting in a most unsightly manner. It would be hard work to give to parents and teachers illustrations which are fraught with graver practical meaning than these. Children should be kept away from sense objects which suggest vicious or unwise courses of action. One reaction to such suggestions modifies the nerve matter. Repeated reactions plough out new paths in this matter, or change its manner of responding to normal stimuli.

As human beings grow older, ideal suggestions come to have more and more force. At first a sensory stimulus is the only cause that will develop movement in a child. It will later start in quest of something in the next room. Here, the idea develops movement. This is a marked advance over the preceding state, when a toy had to be visible before the hands were stretched out to grasp it.

The effects of suggestion are most striking in the case of those ideas which are correlated with prominent motor elements. Some ideas tend toward pronounced movement; others have less of this quality. We may say with Wundt, "The memory image of a movement is apt at once to arouse the movement itself."[1]

A prime condition of motor training is to bring ideal suggestion to bear on young people. Hypnotism shows how powerful this is. As soon as the idea of a possible action is suggested to a hypnotized person, he immediately begins to act in conformity with the idea. If he is told to dance, his feet begin the proper movements. If the idea that he has the toothache is suggested to him, his face is drawn up with pain. The motor force generated by the idea flows out and moves the muscles in the direction indicated by the idea.

A mistake is often made in thinking that only hypnotic subjects are controlled by suggestion. We are all under its influence to a certain extent. The only reason why all motor ideas do not cause us to act in their direction is because some of us have the power of inhibition more strongly developed and are better balanced than others. Suggestion is specially powerful with young people, and it becomes a matter of great importance to know what ideas to bring to bear on them and what to exclude, in so far as possible, from their lives. Several boys in New York State had their minds filled with deeds of highwaymen and train-wreckers. These ideas marked out a path for action, and the boys — some of them of good parentage — actually wrecked an express train and were thereby guilty of murder. Some years ago the daughter of a governor of one of our States eloped with her coachman. The newspapers gave columns to the affair, detailing how the flirtation and familiarity began and progressed. Young ladies read these, and of course had their attention strongly directed toward things which should never have entered their heads. A large harvest of elopements and scandals was reaped. The

[1] Wundt's *Lectures on Human and Animal Psychology*, p. 286.

daughter of a millionnaire soon eloped with her coachman. Trunk murders became epidemic soon after the details of a notable ghastly crime were brought to the attention of the public. Some casual suggestions have started many a boy and girl on the road to an immoral life. Older people who realize the power of suggestion often shudder when they think how easily their lives might have been ruined at some critical time, had they not fortunately escaped certain forms of suggestion which overpowered others.

While the idea of a movement always tends to start the movement, it is true that the will may immediately develop an idea of the consequences of the action, and this second idea may suggest a movement the opposite of the first. The idea of the exhilaration from a glass of strong drink may start a man toward the bar. An idea of some special things which his wife and children lack, or the recollection of a contemptible drunkard of early promise, may stop him. The inhibitory idea is not certain to appear; nor, if it appears, is it sure to restrain the action. Shakspere showed that he understood this, when he has Horatio endeavour to keep Hamlet from following the Ghost:

> "What if it tempt you toward the flood, my lord,
> Or to the dreadful summit of the cliff.
>
> * * * * * * * * *
>
> The very place puts toys of desperation,
> Without more motive, into every brain
> That looks so many fathoms to the sea
> And hears it roar beneath."

If the man really wished to be snowballed, he took the right course in asking the urchin, "Are you going to throw that snowball at me?" We may in some cases even doubt the wisdom of warning children against certain bad practices for fear of putting them into the children's heads. From this, we can see that the antecedent step to getting a thing done is to suggest it forcibly, or, in every-day parlance, "to put it into his head."

If the child's early life is rich in sensuous material or in imitative promptings, there will be motor incentives enough. The trouble will come in directing his acts. With respect to models for imitation, it is impossible to be too careful. Imitative acts soon permanently modify motor nerve cells. On this head, we may say with Guyau: "Intercourse with respected relatives, a master, or any superior whatever must produce suggestions which extend through a child's lifetime. Education has the magic and 'charms' spoken of by Callicles in the Gorgias, of which it makes use to tame the young lions when need arises. These are in man 'thoughts by imitation,' which are transformed from individual to individual, and generation to generation, with the same strength as real instincts. I know a child of thirteen, who had read in *Martin Paz*, one of Jules Verne's novels, the description of a captivating heroine who had a mincing gait, and from that time forward the child endeavoured to take very short steps. The habit is now so inveterate that she will in all probability never be able to rid herself of it."[1]

The acquisition of correct habits is the most important result of motor training. Habit is the process of associating a definite muscular action with a sense impression or with an idea. If a child is properly trained, his motor response to the right will be unerring. Such a child will not stop with a sensation or with an idea, which amount to nothing when divorced from action. He will act in the proper way every time. To show

[1] *Education and Heredity*, p. 15.

more definitely what we mean by an invariable motor reaction to a sensation in order to form a habit, let us show how the habit of putting things in their places is formed. A child should first be taught that the sensation due to seeing a thing out of its place must be followed by the action necessary to put the article in its place. The sensation must so often be associated with the action, that the one shall flow automatically into the other. There must be at once one definite action resulting from the sensation. This is habit. When a good engineer sees a red light on the track before him, the sensation immediately flows into the motor cells governing his arm, and the throttle valve is closed. There is no hesitation, no thought of an alternative course of action.

The way to spoil either a child or a young dog, is to allow it to react to a certain sensation one way to-day and another way to-morrow. Such a child may put a thing where it can be found, occasionally, but no dependence can be placed upon him. A pointer will be worthless as a hunting dog, if he is allowed to point at the game sometimes, and at others to bark or to rush on it.

From another point of view we may define habit as motor modifications in nerve matter, which have become stable through the repetition of actions. This repetition renders actions more easily performed. There is at first friction between sensory and motor nerve cells and this must be decreased. It is much harder work to lock and unlock a new lock than one which has been in use for some time. There are rough projecting particles in the sliding parts, and these will finally be worn so smooth that but little friction will result.

From the broadest point of view, memory is habit. In memory the nerve cells are again acting in a way in which they have acted before. Each repeated action deepens the tendency to act again in the same way. This shows the reason why we remember most easily things or acts which have been most often performed. Thus, we never forget the alphabet or how to walk, so long as our nervous system is not diseased.

We may be asked to state precisely what happens in the central nervous system when habits are formed. There are two hypotheses to answer this. First, there is a new path ploughed out in nervous matter, so that a motor discharge proceeds more directly and more easily from one cell to another associated one. It sometimes happens that when we wish to go from one place to another, the railroad proceeds only in a roundabout way. At a certain junction we must wait and change cars. Suppose, however, that a new track is laid in an air line between the two places and that no change of cars is necessary. The journey can now be made much more quickly and easily than before. When we have had little repeated activity of the right sort in doing a certain thing, we are like the person who travels two sides of a right-angled triangle, *e.g.* the base and the perpendicular, instead of going by way of the hypothenuse. Habit of the right kind discovers that any two sides of a triangle are together greater than the third side, and travels by the shortest path.

The second hypothesis maintains that there may be no new path formed in nerve matter because of repeated actions which lead to habit. This hypothesis uses the illustration of a new lock which is moved with difficulty. Although no new path is formed in which the lock slides back and forth, it is yet locked and unlocked more easily with use. The rough points in the old path are worn away so that there is less friction. It may be that repeated dynamic associations between cells clear out the path and reduce friction. A current of water in a stream may at last wear its bed smooth, so that the water may flow on more rapidly because there is less friction from projecting particles.

It is not improbable that both theories may be true; that not only may new and shorter routes of brain travel be developed, but also that existing paths may be employed with greater facility.

When a piece of paper is folded, it can again be folded much more readily in the former crease. Suppose some one asks us to explain why this is the case. Very likely we shall say, "Here is a piece of paper which does not fold readily in any special place. We now crease it through the middle. You can see for yourselves that it will now fold readily in the middle." Of course, this is no explanation, but our failure to explain facts does not disprove their existence. We may say that there is a new molecular arrangement in the paper, and that it folds more easily because of this. Of course the next question comes promptly: Why is a new molecular arrangement better than an old for this purpose? Because this is the nature of molecules. This is plainly no answer, only a confession of ignorance. This answer stated in another way is: A new molecular arrangement facilitates habit because a new molecular arrangement does facilitate habit.

The "why of the why" cannot be more satisfactorily answered in neurology than in other sciences. The illustration of the paper has been employed to show that if we cannot tell why paper folds more readily where it has before been folded, we should not be surprised if we cannot fully understand the changes in the brain corresponding to the formation of habit. We may not be able to explain why practice facilitates actions, but the practice is just as efficient as if we could.

We may gain another view of habit by considering it organic memory. In strictest truth, all habit is memory; it is acting again in a way in which we have acted before. This organic memory may or may not be accompanied with consciousness. The organic memory of walking remains with us. A soldier may be conscious of the steps he is taking, but he has been known to march with regular steps while asleep. We frequently tie our neckties without thinking of the operation. The memory is organic, and when the first chain in the link is started, the remaining complex actions follow automatically.

Unconscious organic memory alone renders possible our conscious intellectual lives of great richness and breadth. Man's intellectual achievements would be comparable to the stunted vegetation of the polar regions, were it not for the fact that his unconscious organic memory takes upon itself the execution of myriad perplexing details. Excellent servants, who relieve the mistress of the house of the majority of cares, afford an analogous illustration. She has time left to improve her mind, and to entertain her guests. When we are talking, we are pitiable slaves if we have to centre our attention on the pronunciation and grammar, and thereby subtract so much from the thinking power. Suppose that there occur in a speech we are making such words as deficit, suite, gondola, dolorous, irreparable, naïve, piquant, soughing, levee, — if we have been habituated aright, that is, if there is an organic modification corresponding to the correct pronunciation of these words, their unconscious enunciation will be right, and our attention can be centred entirely upon the stream of thought.

Correctness in grammar, deportment, table manners, — in all actions, in short, — depends on proper motor modifications in the central nervous system. The same is true of expertness in any muscular movements, whether in moving the vocal chords so as to speak a foreign language correctly, or in fingering the piano. After the plasticity of the nerve cells has passed away, the correct pronunciation of a foreign language can never be acquired.

For the formation of habits, there must be repetition of dynamic associations between nerve cells early in life. For instance, suppose one wishes to be a ready speaker. Associations must be formed between cells in different parts of the brain and the motor cells controlling the vocal chords. If the speaker wishes to describe something that he has seen, practice must have increased the associational efficiency of the paths between the sensory centre for sight in the occipital lobes, and the motor centre for speech. If something that he has heard, smelled, touched, or tasted, is to be described, there must be dynamic associations between different brain tracts. If the description is to be written instead of oral, there must be facile. associations between these tracts and that portion of the brain concerned in moving the hand and fingers. The size of the brain and the number of its cells make far less difference than the way they are associated. Good roads and easy means of communication between different parts of a country are essential to its prosperity. The same analogy holds true of the brain.

Ribot puts the case correctly and clearly, when he says: "Organic memory supposes not only a modification of the nerve elements, but also the *establishment between them of associations adapted to each special action* — of certain dynamic associations which by repetition become as stable as the primary anatomical connections. In our opinion the thing that is of importance, as supplying a basis for memory, is not only the modification impressed upon each element, but the way in which sundry elements are grouped together to form a complex.

"A rich and well-stored memory is not a collection of impressions, but an assemblage of dynamic associations, very stable and very readily called forth."[1]

In like manner Hering says: "All living substance, especially nerve matter, has the peculiarity that every irritation produced in a limited region at once spreads to the adjoining parts. It continues spreading as long as it meets with any substance which is capable of being similarly irritated, and which, so to speak, responds to such irritation.

"If the virgin substance of the brain is excited and internally agitated by an irritation which has been transmitted through the nerve fibres of the sensory organs, an increased ability to reproduce the same kind of irritation is acquired by a permanent change of its internal structure. If the sensory nerve again transmits the same irritation, the cerebral substance responds to it more easily."[2]

Habit is, therefore, a bundle of memories or tendencies to act again in a way in which we have acted before. Herein lies the tremendous importance of early actions. Their results do not end with the setting sun; they are as imperishable as ourselves. To-day a man does something which he willed ten, twenty, thirty, or forty years ago. It may be that he would gladly have left the deed undone, but the time to have reflected on the undesirability of such an action was not when it was last committed, but at its first occurrence, perhaps forty years before. One action fitted the nerve tract to act with greater ease in the same way again. By repeated

[1] *The Diseases of Memory*, Chap. I.

[2] *The Specific Energies of the Nervous System.*

motor responses in certain ways, the boy moulds his nervous system so that it will continue to react in the same way. At the start he may be master; at the end he will be slave. It will be well if he is the slave of a sensible master; if his automatic responses are such as he would have made after due deliberation.

Those children are specially fortunate who are compelled to acquire certain proper motor reactions before the reasons for them are understood. Such children will find out later that they have a wonderful mechanism properly fashioned to their hand. When the workings of the central nervous system are more widely known, there will be a reaction in favour of blind authoritative training early in life; that is, if fit parents and teachers can be found to apply such training. Many a young dog has had to be whipped mercilessly to be taught to acquire habits which could have been easily formed in puppyhood. Many young men are dismissed from positions because habits of civility, self-restraint, and punctuality were not ingrained into the nervous tissue before their value was known. These losses of positions and unfitness for certain stations in life may be as hard for the young man to bear as the merciless whippings necessary to correct a dog which had not been properly trained. Even inanimate things can acquire the habit of making wonderful reactions to stimuli. It is well known that the wood of a Cremona violin, which had been used by the hands of none but masters, gradually acquired a molecular tendency to harmonious resonance. When the instrument was afterwards used by an ordinary player, he was astonished to find that it had a tendency to play well of itself and to refuse to respond to his mistakes by introducing the amount of discord to which he was accustomed. The sooner the idea is exploded that a child should not be taught until it can see the why and wherefore of things, the better it will be for the world.

If motor training in its initial stages were to depend on the thinking power of the individual undergoing the training, there would be little progress made until the nervous system had in great part lost its plasticity. Many persons would receive scarcely any training, were it not for the fact that their nervous systems are compelled to undergo motor modifications by intelligent parents. There are hourly illustrations of this. The parent makes the child say "he sits down" in place of "he sets down," "the sun sets" in place of "the sun sits." The child may not understand why he should use "sit" and "set" both intransitively, but he grows up as correct a speaker as if he could explain the inexplicable. He is not compelled to think which form is correct; he can be thinking about something else, while the motor reactions of speech are habitually right. No person can think about two different things at the same time with great force, and the thinking hours of life are limited. To show how dangerous it is to leave an individual's training until he is old enough to think out the reason for it, we may quote one of the most eminent German psychologists: "The old metaphysical prejudice that man 'always thinks' has not yet entirely disappeared. I myself am inclined to hold that man really thinks very little and very seldom. Many an action which looks like a manifestation of intelligence most surely originates in association."[1]

From what has already been said, can be seen the importance of becoming a motor automaton in certain directions early in life, so that thought can be occupied with higher duties. When we began to walk, the whole power of con-

[1] Wundt's *Lectures on Human and Animal Psychology*, p. 363.

scious will would have been necessary to direct the movements. We could not have thought about anything else at the time. When the child first tries to form a letter of the alphabet, his whole power is expended in controlling the muscles. If a philosopher had lived until the age of forty without learning how to write, it would be some time before he could form the letters and think of fitting ideas to be expressed at the same time. When writing comes to be largely the result of an automatic discharge of motor cells, one can centre almost his entire attention on the thought while writing at great speed.

Wundt's remarks along this line are especially good. He says: "Any movement that has become altogether habitual is made instinctively. An impulse of will is, of course, necessary at the outset; but its effect extends to a whole series of actions, and each particular one takes place without effort and without knowledge: the series once started is continued to its end with the same unconscious certainty and purposiveness as the reflex. The voluntary movements of early childhood are uncertain and awkward; practice has not had time to transform them into instinctive acts. And the same is true of the adult whenever he wishes to perform some as yet unaccustomed action, of however simple a character. Precision and grace of movement, then, depend upon certainty of instinct, not upon firmness of will.

"This transformation of voluntary into instinctive activity is greatly furthered by the influence of the environment. From the first days of life we are surrounded by our fellow-men, and imitate their actions. And these mimetic movements are instinctive in character. As soon as the child's consciousness is aroused from its first sleepy passivity, it begins to perceive the expression of others' emotions, and to respond to them by similar emotions with corresponding impulses. The continued imitation by which a child comes to learn the language that is spoken around it, is impulsive, not voluntary. Even the peculiar word-formations of child-language are not, as is often wrongly held, invented by the child, but borrowed by it from its environment, — from the words of nurse and mother, who, in their intercourse with it, adapt themselves to its level of mental development and capacity of articulation.

". . . the simplest conditions of instinctive action in general are to be found in the cases where it is the result of individual practice. Here the action simply indicates a disposition of the physical organization, which has been induced by movements often repeated in the past. The performance of a definite complex act and its connection with an adequate sense stimulus have become more and more matters of course, till at last they are rendered completely mechanical. . . .

"The effect of 'practice' and of 'habit' can only be due to after effects of excitation, of the kind assumed by us for the explanation of instinctive movements. And, since the expressions of instinct are, *par excellence*, 'customary' or habitual actions, their subsumption to the general law of practice needs no justification. That law runs as follows: the more frequently a voluntary action is repeated, the easier it is to perform, and the greater is the tendency of its constituents (if it is a complex act) to take on the reflex form, *i.e.* to arrange themselves in a connected series of movements, which runs on mechanically when once initiated by an adequate stimulus.

"The formulation of this law shows us at once that its basis must be physiological. The goal attained by the process of practice is simply the mechanization of movements which were originally dependent upon psychical antecedents. That must mean that mechanical, *i.e.* physiological, alterations of the nervous system are at the bottom of the whole matter. We are still so much in the dark as regards the real nature of nervous processes, that we need not be surprised to find the exact physical and chemical character of these alterations quite unknown. If we know nothing more about them, we are quite certain they exist; the witness of the actual results of practice cannot be called in question. There is hardly any movement of the human body, however difficult, which we cannot, by continued practice and repetition, reduce to a mechanical certainty so complete that it will be performed, even without any intention on our part, as the necessary reaction to certain sense-stimuli."[1]

Dr. Carpenter's conclusions in the same line are also specially interesting. He says: "The extraordinary *adaptiveness* of the organism of man is shown in his power of acquiring a vast number of more *special* actions, which have no direct relation to his bodily wants, but minister to the requirements of his own creation. These often become, by a process of prolonged 'training,' not less automatic than the act of walking; as is shown by the fact that, when once set going, they will continue in regular sequence, not only without any volitional exertion, but whilst the attention is wholly directed elsewhere. Thus, a musical performer will play a piece which has become familiar by repetition, whilst carrying on an animated conversation, or whilst continuously engrossed by some train of deeply interesting thought; the accustomed sequence of movements being directly prompted by the *sight* of the notes, or by the remembered succession of the *sounds* (if the piece is played from memory), aided in both cases by the guiding sensations derived from the muscles themselves. But further, a higher degree of the

[1] Wundt's *Lectures on Human and Animal Psychology*, pp. 395, 402, 403.

same 'training' (acting on an organism specially fitted to profit by it) enables an accomplished pianist to play a difficult piece of music at sight; the movements of the hands and fingers following so immediately upon the sight of the notes, that it seems impossible to believe that any but the very shortest and most direct track can be the channel of the nervous communication through which they are called forth. The following curious example of the same class of acquired aptitudes, which differ from instincts only in being prompted to action by the will, is furnished by Robert Houdin:

"With a view of cultivating the rapidity of visual and tactile perception and the precision of respondent movements, which are necessary for success in every kind of 'prestidigitation,' Houdin early practised the art of juggling with balls in the air; and, having after a month's practice become thorough master of the art of keeping up *four* balls at once, he placed a book before him and, while the balls were in the air, accustomed himself to read without hesitation. 'This,' he says, 'will probably seem to my readers very extraordinary; but I shall surprise them still more when I say that I have just amused myself with repeating this curious experiment. Though thirty years have elapsed since the time I was writing, and though I have scarcely once touched my balls during that period, I can still manage to read with ease while keeping *three* balls up.'

"This last fact appears to the writer to be one of peculiar significance; for it seems to justify the conclusion that even a most complex series of actions, which essentially depends on guiding perceptions, may be performed by the automatic mechanism, without any other volitional action than that which 'starts' it, when once this mechanism has been developed by the *habitual exercise* originally imposed on the nerve centres by the will. And further, it shows that this mechanism, having been originally so shaped *at an early period of life*, is kept up by nutritive action, even though not called into use; just as the 'traces' of our early mental acquirements are persistently retained in our organism long after we have lost the conscious memory of them."[1]

A study of motor reactions and their resulting habituations shows us why education should consist largely in doing. The act of doing results in changed physiological disposition. It is of little use for one to be told, or to read, how anything is done, unless he follows this with the appropriate actions. Telling one how to ride a bicycle, develop a negative, tie a knot, perform a chemical experiment, or make an article, is of very little use; but if the learner, under the proper guidance, is made to perform the necessary actions, he is on the only royal road leading to the desired result. The writer was once shown how to tie a flat knot and a bowline knot. Instead of making him take the rope and perform the complex movements under guidance, the instructor did all the tying himself. As a result, the writer cannot to-day tie a bowline knot.

A triangle or a square means more to a boy after he has drawn it, and still more after he has carried a surveyor's instruments around and actually measured the ground within the square. Pupils will absorb only so much of history or of literature as they can interpret in terms of their own *active* experience. Fortunately, the power of suggestion tends to make the young imitate the actions of others. Those who have watched children after they have been taken to a factory or a circus can testify to the truth of this. If some youths are given a simple newspaper account to read, they mangle

[1] Carpenter's *Mental Physiology*, pp. 217, 218.

it terribly, mispronouncing and miscalling the words because the motor speech cells have not had sufficient practice in reading.

Action is the key-note to habit and character. If a habit in a given direction is desired, act in that direction. If one wishes a garment or a piece of paper folded in a certain way, he must be sure to see that the first folds are made in the proper way. Any one can soon demonstrate how well the nervous system is adapted for the formation of habits and how hard it is to overcome the effects of previous action. Give a child a pack of cards to sort by suits. Have him put hearts well over to the right side of the table, clubs to the left, the other suits at well-separated intervals. Make accurate note of the time it takes to sort the pack. Gather the cards up and shuffle them as before, then have the child place clubs to the right, hearts to the left, and the other suits out of their former places. He will now be an appreciably longer time in sorting the pack. The reason for this shows how speedily a tendency toward habituation is formed. The sight of hearts had been associated with a muscular movement to the right, and during the second sorting the muscles will tend to move in the direction required for the first sorting. The inhibition of this movement and the turning it in the proper direction take additional time. In so far as possible, we ought to do a thing at first as it will be required to be done for all future time.

In the case of young children, we must remember that they gain control of the larger muscles, *e.g.* those of the shoulder and limbs, first. We must not expect a child to acquire for some time movements of the fingers sufficiently precise to trace a fine copy in a writing or drawing book. But since we get all things in life through action, we must remember that motor tracts need as careful training as sensory tracts, and that *there may be undeveloped motor, as well as sensory, cells in the central nervous system.* These spots will remain permanently undeveloped, unless they receive the proper modification while still plastic. The writer knows persons who in vain tried in middle life to acquire the necessary correlation of movements for swimming. These movements could have been gained easily and pleasantly while the motor cells were plastic, and, in many cases, drowning might thus have been avoided. We also occasionally see persons of both sexes, not over thirty, who, from lack of early motor development, cannot balance themselves sufficiently to learn to ride a bicycle.

Above all, we must guard against ideas which do not result in action. The idea exists only as a prompter to action, immediate or remote. If the idea is of the right kind, the action need not be feared. The great danger from castle-building and inveterate novel-reading lies in divorcing ideas from action. The dreamer accustoms himself to become incapable of action. In the proper scheme of training every sensation and resulting idea should be made to have a bearing on action. Some valedictorians have amounted to little in the outside world because their ideas did not lead to action.[1]

[1] For further consideration of the importance of associating action with ideas, see Halleck's *Psychology and Psychic Culture*, pp. 355-358.

CHAPTER XII

The Central Nervous System and Enjoyment

We shall in this chapter very briefly discuss the relations of the central nervous system to enjoyment, and we shall endeavour to ascertain how the training of that system affects the pleasures and the pains of life.

This is not the place to decide whether enjoyment is wicked and should therefore be discouraged, whether the only ethical nervous system is one that will not allow its possessor to enjoy himself, or whether the poorly nourished irritable nerves of the dyspeptic are most serviceable in the cause of morals. In mediæval times, all bodily pleasure was considered sinful. It was thought right to starve and mutilate the body.

This belief has not wholly passed away. We find an occasional modern writer saying that it is not worth while to cultivate the senses of taste and smell for the purpose of getting pleasure from them. The pleasure from eating a peach with a cheek like the dawn, or from inhaling the odour from a bank of roses, is merely nerve pleasure, and as the devil is the original creator of the nervous system, all pleasure springing from it must be unholy.

The physiological psychologist of to-day pays no attention to these mediæval opinions. He knows that all pleasure, from the highest to the lowest, rests either directly or indirectly on the workings of the central nervous system. He knows that the colours of the rainbow stimulate pleasurably the rods and cones in the eye, that the "breath of incense-breathing morn" has the same effect upon the nasal nerves. He has seen weakly persons, who attempted to give proper intellectual and emotional response to some noble altruistic deed, seized with a severe headache because the nerve cells were too feeble to afford the fitting physical substrate for this higher action of the soul. Vigorous and well-nourished nerve cells are an absolute requisite for the pleasures of the higher realms of thought and emotion.

Life is not so rich in pleasures that we can afford to throw away a single one. Enjoyment is just as much enjoyment, is as divinely given, when it results from the odour of violets, the taste of a strawberry, the rhythmical sound of a simple melody, the touch of down, or the sight of autumnal foliage, as from any other form of action. The fact that we may have genuine nerve pleasure from sensory experiences with these objects is no reason why we should not advance to enjoyment of a higher kind. This nerve pleasure is rather a necessary preliminary to higher types of enjoyment; for we notice more carefully what gives us simple pleasure, and careful observation is a prerequisite to the higher intellectual life. The one who defrauds himself, or has his teachers defraud him, of any of the normal pleasures of even taste or smell, is losing a part of his birthright in life.

Those persons who decry proper enjoyment of any kind are invariably hard and cold, unimaginative, and undesirable for companions. The man who experiences genuine happiness in eating a juicy peach will be much more apt to bring one to his child and to think how the little fellow will enjoy it. In the generality of cases, nerve pleasure within proper limits means the furtherance of the life and well-being of the individual; while pain is an alarm signal to warn us that we are suffering harm. Where we find an individual whose nerve cells are sufficiently strong to respond with pleasure to many of the stimuli of life, we have one who is also specially fitted for enjoyment in higher fields.

A brief study of the way in which pleasure is related to the condition of the nervous system will enable us to lay down some rules that will be of practical benefit. Pleasure is always the result of the use of stored force of some kind or other. This force may be physical, monetary, or intellectual. All kinds of force, with the different varieties of pleasure resulting therefrom, rest upon physical well-being as a foundation.

Whenever nerve cells have accumulated an excess of energy, pleasure always accompanies working this off in a normal way. The desirability of accumulating this stored force is therefore evident. After this energy has been expended, pain results if the action is persisted in. Any of the muscular movements illustrate this truth. A piano player or a hunter will find pleasure in discharging the stored energy in the motor nerve cells in the varied movements necessary to strike the keys, or find the game. There, however, comes a time, which varies in different persons, when the energy is exhausted, and further movement causes pain. Any person who has spent much time in a large picture gallery has perhaps experienced great pleasure in looking at the paintings for an hour or two. If he keeps on his feet studying the pictures for a much longer time, weariness and pain ensue, because the surplus energy has been rapidly drained off by the muscular and intellectual efforts involved in the study. Whenever a nerve cell, after parting with its stored force, is called on to keep responding to the same stimulus, pain results.

Marshall[1] expresses the laws of pleasure and pain concisely:

[1] *Pain, Pleasure, and Æsthetics*, p. 218.

"We may properly say that all pleasure is the coincident of the use of surplus stored force, and that all pain is the coincident of organic conditions, which imply that the energy of reaction is less than that which should be expected to result from the stimulus reaching the organs, whose action determines the mental elements in each case." We can see why attention, which depends on brain cells for its physical basis, cannot be long continued with full intensity. The correlated nerve cells are all the time parting with their energy, and there must soon be a period for recuperation. The brain is at its best for only a few hours of intense action each day. We can thus see how precious attention is. It will not remain long at its maximum, and the hours of life are extremely limited when we can employ attention at its high-water mark. We ought, therefore, to be much more careful of wasting such a power than of squandering our money.

We must now consider the practical question: How shall we increase the amount of stored nerve force? Is there any available way for enlarging the storage facilities of cells? Fortunately there are methods which the weakest persons in the world can employ for gradually strengthening their cells. Whenever any part of the body is exercised, more blood flows there. Now, this blood is laden with nutriment which strengthens that special part. Suppose that we are exercising our ears, listening to the songs of birds and discriminating between them. This act of attention sends more blood to the cells in the temporal lobes, and also to the parts of the brain intimately connected with them. The cells thus receive more nutriment, and increase in vigour and capacity. If, when blindfolded, we endeavour to discriminate between different flowers by the sense of smell, more blood goes to the olfactory brain cells. They become stronger, and capable of storing more energy. Perhaps a year later, in a different locality, we experience a thrill of pleasure from the recognition of a flower. Our capacity for enjoyment has increased because of this sensory exercise.

Even the higher processes of thought affect the brain, as the rise in delicate thermometers placed against the scalp, testify.. As the cells correlated with thinking are exercised, and therefore grow stronger, intellectual action becomes more pleasant. A well-trained nervous system ought to have a large amount of stored force which can be pleasurably used in the various forms of intellectual, emotional, and voluntary action. In every way in which we wish to obtain any of the higher forms of enjoyment, there must have been previous exercise along this special line. If we wish to appreciate poetical passages relating to the beauties of nature, this power will be due to the fact that the stimuli from those objects have affected the brain. The energy from these stimuli is stored in the brain in the altered condition of the cells whereby recognition and assimilation are possible. As we are more specially concerned with sensory and motor modifications, we must again call attention to the importance of the proper exercise along these lines as the foundation for future happiness. Enjoyment of the higher intellectual kind will come naturally if there are good foundations on which it can rest.

A study of pain is also valuable, for it is so closely related to pleasure. After the stored nerve force has been exhausted, pain results if the same stimulus continues to be applied. Pain is, therefore, seen to be as useful as an alarm bell, which signifies the existence of danger. If no pains were present, or if we disregarded them, we might speedily destroy our bodies. When we grasp a hot iron, the pain is useful to warn us to drop an object which is injuring us. There are, however, some pleasurable forms of activity which impair the system; as, for instance, some injurious chemicals have a pleasant, sweetish taste. Hence, in these matters, we must listen to the voice of experience, that of our ancestors, as well as our own. Marshall[1] states the case correctly when he says: "The laws of survival and development, however, will, in the long run, bring about a *general* correspondence between the conditions of pleasure and individual advantage, and the conditions of pain and individual disadvantage; but, with this *general* correspondence, we must expect to find many exceptions, as we do find many of the sweets of life disadvantageous to us as individuals, and many of its bitters advantageous."

When we are developing any power, we shall frequently find that a certain amount of pain is a necessary antecedent to increased development. Suppose that a girl feels pleasure from the use of her muscles during a three-mile walk in the country. If she stops walking the moment she begins to feel slightly fatigued, she gains very little additional power. If she now walks three and one-half miles, that is, half a mile beyond the point where she feels no fatigue, she will put her motor cells, and the muscles controlled by them, in the best possible condition for assimilating more nutriment. Other things being equal, the fatigue point will be removed farther away, and she will not even begin to feel tired after finishing three and one-half miles. She may, by thus gradually developing her powers through exercise and the consequently increased capacity for assimilating nutrition, come to enjoy a walk of twenty miles, as many English girls do.

We have already seen that exercise decreases the volume of the nerve cell, and that fatigue must not be pushed beyond the point where rest and nutrition cannot speedily restore the powers of the cell. Occasionally too great a strain is imposed on the nervous system, and it never regains its normal vigour.

[1] *Pain, Pleasure, and Æsthetics*, p. 218.

In general, however, we may say that youthful nerve cells not only speedily recover from ordinary fatigue, but they also gain additional vigour from such exercise. This is not the case with persons who have passed middle life. In old age, the cells recover from fatigue very slowly and incompletely.

Acquired tastes are frequently the source of many of the pleasures of life. There are many things in which we take no interest originally, things which are positively distasteful at the start, but from these we often grow to receive much enjoyment. From repeated exercise, the nervous system acquires new storage facilities, and new pleasures are the result of using this stored energy. "The entrance to most studies is attended with painful labour; but, after a while, they become sources of positive pleasure. It has been well said that acquired tastes are so many acquired ways of getting pleasure from things which were once distasteful. Raw oysters, tomatoes, and pickled olives are physical instances. Many studies furnish mental illustrations." [1]

There is no point in the relations of the nervous system to enjoyment more important than a knowledge of the fact that the foundations for enjoyment must be laid in youth, while nerve matter is still plastic. It may be hard work to teach an old dog new tricks; but it is still harder work to get him to *enjoy* them. Later in life one cannot enlarge the storage facilities of the nervous system to any great extent, nor can he easily acquire new tastes. After parents have passed the greater portion of their life in a treadmill of hard work, their children have sometimes taken them away on a trip to provide enjoyment for them. The parents have not infrequently been wretched because they could no longer adapt themselves to new situations.

[1] Halleck's *Psychology and Psychic Culture*, p. 244.

During a period in the life of every boy and girl, the nervous system is ripe for a certain course of action. If this period is allowed to pass without exercise in the special directions fitted to secure various kinds of enjoyment, the early plasticity is soon lost, and this exercise, if attempted later, will prove irksome. A striking illustration of this was shown in the case of a gosling which was reared in a kitchen away from water. After several months, it was taken to a pond, but refused to go in. When the gosling was thrown in, it hurried out, like a hen, in a frightened way. The desire for swimming had been suppressed. The fact that the nervous system will at a certain time react to stimuli which fail to affect it a little later, is shown in the case of chickens. A short time after hatching, the clucking of a hen will develop motor reactions which cause them to follow her. If the chickens are kept away from the hen for a week, the clucking never calls forth the usual motor response, but they will then follow the whistle or call of any person to which they have been accustomed from birth. A puppy brought up on a hard floor will frequently make a feint of burying a bone, but as the early environment is unsuitable for developing the instinct, it is often altogether abandoned, although the grown dog may be allowed to wander at will where the earth is soft. Darwin found that a species of caterpillar naturally fond of the leaves of a certain kind of plant would soon lose its liking for them, if accustomed at birth to eat a different leaf. So pronounced does this dislike become, that worms have been known to die rather than eat the favourite leaf of the species, if they have been reared on different food.

Lack of fitting exercise at the time when the nervous system is ripe for response is dwarfing in the case of human beings. In this way, their field of enjoyment becomes very narrow; the situations that are irksome or positively painful are extremely numerous. One can frequently see at recess, around the edges of the yard of an advanced school, boys who never participate in the sports. In many cases these boys were not allowed to play with other boys or to acquire a liking for games while the nervous system was adaptable and ripe for these special kinds of action. A liking for travel, music, studying animals, — indeed, for all the special kinds of sensory exercise in connection with certain objects, and for the proper motor responses thereto, — must be acquired when the nervous system is ripe for them. It is useless to plant Indian corn in the autumn, and it is equally useless to expect to receive pleasure from the nervous system in varied forms of exercise, if these have not been tried when the nervous system was ready to be moulded by them.

We may, therefore, lay down this general rule of procedure in order to augment the pleasure-giving powers of nerve cells: To increase the strength and storage capacity of the nervous system, subject it to the proper exercise, in as many varied directions as possible, in youth. This exercise lessens the volume of nerve cells and leaves them in a state where rest and an increased assimilation of nutriment are necessary. Physiologists have demonstrated that more blood carrying nutritive materials flows to cells that are exercised than to those that are not. Herein lies an additional reason for the early exercise of all brain tracts, sensory and motor alike, since they will thereby gain more nutriment and strength.

We come now to consider the effect of habituation and automatic motor responses to stimuli. We have seen in the last chapter that habituation so decreased the friction in actions that they came to be performed with less and less consciousness. The watch is wound, the word mispronounced, the error in grammar made, the ungraceful movements continued, without consciousness of the character of the action. On testing our watches, we are frequently surprised to find that we have wound them. We can scarcely believe that we have mispronounced the word, or made the grammatical slip.

The relations of habituation to enjoyment are properly studied because pleasure is an accompaniment of consciousness, and habituation tends to cause the usual motor responses to take place without the intervention of consciousness, and often distinctly below its threshold. Still more important is the fact that pleasure depends on the use of stored nervous force. The more habitual the action, the more constant the drain on the nervous reservoir, and the less will be the accumulation of energy. In order to store this, there must be periods of rest. Habitual action keeps the faucet turned on the most of the time, and as soon as a little energy accumulates, out it flows.

The occupations of the majority of humanity involve a treadmill routine, and we can, from the foregoing considerations, the better understand why there is so little pleasure in the steady vocations of life. The actions necessary in them not only become more automatic and are correlated with less consciousness, but they also drain off the nervous energy as fast as it accumulates. For this reason we hear so many people advising against choosing their own profession or business. They realize that their own has given them little keen enjoyment, and they conclude that some other would necessarily be more pleasurable.

It is true that some vocations are subject to less routine than others, and some are for that reason the more enjoyable. The student in many lines does not keep repeating the same facts, but he proceeds from new truth to new truth, frequently making novel discoveries as long as he lives. The book-keeper, on the other hand, is constantly busy with the same ten numerals.

If any life is to be rich in enjoyment, the principle of contrast must be employed. By following contrasted lines of action, the energy stored in some cells can be used while the others are resting. The optic nerve apparatus yields pleasurable sensations as soon as acted upon by the stimuli of the buds and blossoms of the spring. The nerve cells have been storing force all winter, and hence for some time the response to the leafage and blossom of tree and flower is very keen. Since these stimuli remain well-nigh constant, they rapidly drain off the accumulated energy, and the pleasurable response becomes less marked. By midsummer we often find ourselves scarcely noticing the leaves, unless there is about them some novel feature that strikes our attention, such as an added glow of freshness from dew or rain, a pleasant noise from their rustling in the wind, or the tossing of the branches in a storm. After a change of boarding place, persons often think the food at a hotel is unusually good; but the bill of fare varies little from day to day, and finally the viands seem so monotonous that but slight pleasure is experienced in eating. Druggists say that they often sell a great deal of soda-water in the spring before it is very warm. This drink then seems unusually good, because none has been tasted for a long while. They allow the boys who tend the fountain to drink all they choose. For the first few days, the boys consume a great deal, but they become less and less fond of it.

Is the nervous system, then, so constituted that its habitual and automatic actions must be productive of slight enjoyment? The facts in the case demand an affirmative answer to this question. How, then, is enjoyment to be secured? The conditions of life are such that automatic expertness is necessary in most lines, whether in weaving a piece of cloth, playing a musical instrument, or attending to the routine of business. The successful man in any trade or profession must make his expertness a matter of ingrained neural habit. There must, therefore, necessarily be in most vocations little keen enjoyment. The well-worn neural paths constantly allow the escape of the energy without an act of will, or indeed of more consciousness than attends many reflex acts.

The most marked pleasures are to be obtained from the side issues of life. Hence, then, the question, How is enjoyment to be secured? should be answered: Not from the vocations, but from the avocations of life; not from the treadmill, but from those occasional excursions into the bypaths of novelty, or rather of intermitted action. If the business man is a lover of flowers, plants, and trees, he will take far more pleasure in his garden and orchard than in his business. He may wish that he could give all his time to them, thinking that enjoyment would be continuous. But he forgets that the novelty would then wear off, and gardening would become a humdrum business. The amateur takes keen delight in photography on his summer trips, but the professional finds it as much of a treadmill as most other vocations. Every person should have some side issues which he finds productive of enjoyment. These may be developed at every turn. Music, horses, boating, fishing, reading, gardening, collecting various things, from old books to rare china, participation in philanthropic movements, travelling, an amateur knowledge of ornithology, botany, and myriad other things may furnish many side excursions into a land of pleasure.

Marshall's remarks on this line are well considered. He says: "All habitual exertion, whatever be its field, must become indifferent, and in all cases we must turn to paths not too commonly trodden if we are to obtain pleasure.

Richelieu amused himself by writing bad tragedies; Darwin by reading crude novels. . . .

"The use of well-rested organs is the basis of the pleasure-seeker's universal search for *novelty;* not absolute newness, but new arrangements of activities which have been customary, but not lately repeated; restoration of stimuli which for some time past have not acted upon us. . . .

"We have learned that the man who by overwork has lost all interest in things, all capacity for enjoyment, has exhausted his system as a whole, and needs entire rest if he is to regain this lost interest. We have learned that loss of interest in one special line of activity is to be regained only by working in new lines, to the exclusion of the one in which we have overworked."[1]

On its negative side, habit is not inimical to enjoyment; for no one can enjoy himself unless he has formed good habits. Actions that are at first genuinely disagreeable grow to be neutral after we have become habituated to them. The vocation of many a one is irksome, even irritating, at the start. As he looks toward the future, he wonders how he can long endure the jarring and the nervous friction. Habituation soon decreases these, and the nerve currents glide along smoothly and automatically in the performance of the customary tasks. It is well that habituation removes the sting from many employments; for the street-cleaner, hod-carrier, night-watchman, accountant, fireman, engineer, pilot, boiler-maker, are necessities in life. The capacity of the nervous system for habituation makes their life tolerable. *The effects of habit go as far toward decreasing pain as toward lessening acute enjoyment.*

In this work, the early development of all the sensory and

[1] *Pain, Pleasure, and Æsthetics,* pp. 230, 257, 258.

motor powers has been urged, in order to make knowledge complete and to achieve success in the world of action. There is a further reason for the early development of as many capacities as possible, for these may afterward become the by-paths of enjoyment. Later on in life, we cannot mark out new paths, but we can traverse old ones with much pleasure. If we store force in our youthful brain cells by giving them full sensory exercise and having them make the proper motor responses thereto, a renewal of these forms of action will be pleasurable in later life. The man who has been away from the country for many years finds great enjoyment in again identifying the birds by their song, in hearing the wind sighing through the pines, in recognizing a wild flower beside a murmuring brook. This will prove true only in case he has passed through these experiences in youth. Action on entirely new lines is generally irksome after the nervous system has passed the plastic stage; but the repetition of former enjoyable actions will then rarely fail to give pleasure.

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